



Assimilation of atmospheric chemistry satellite observations

Henk Eskes, Vincent Huijnen - KNMI

GEMS/MACC colleagues: Hendrik Elbern, Antje Inness

Colleagues from RIVM en TNO

- The GEMS / MACC project
- Model - satellite comparisons
- Assimilation on global and regional scale:
ozone and NO₂



The ‘Global Monitoring for Environment and Security’ (GMES) represents a concerted effort to bring data and information providers together with users, so they can better understand each other and make environmental and security-related information available to the people who need it through enhanced or new services.



“GMES Atmosphere Service”: the GEMS project

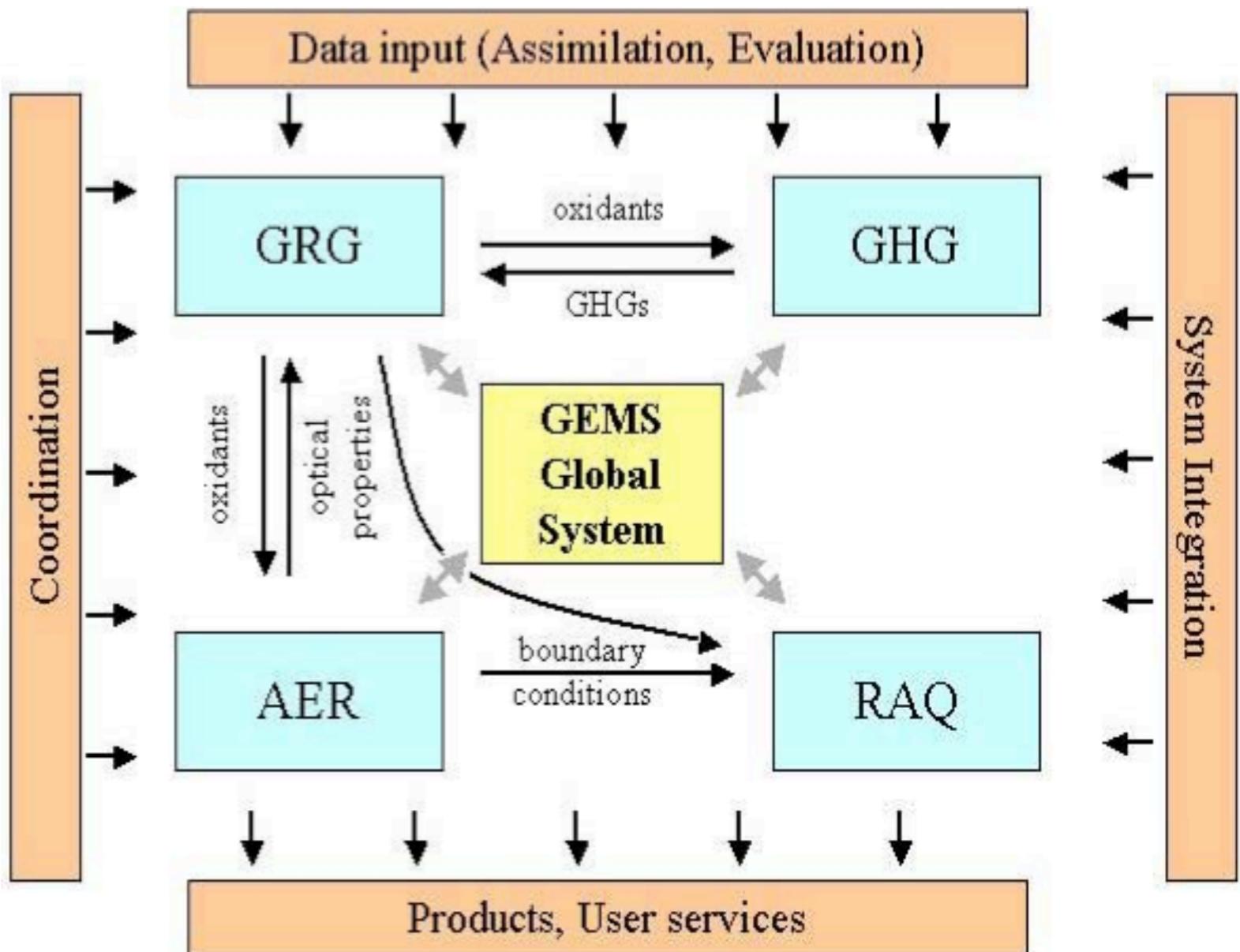
Global & regional Earth-system Monitoring using Satellite and in-situ data

EU 6FP, GMES, 2005-2009, 27 partners

Coordinator: ECMWF

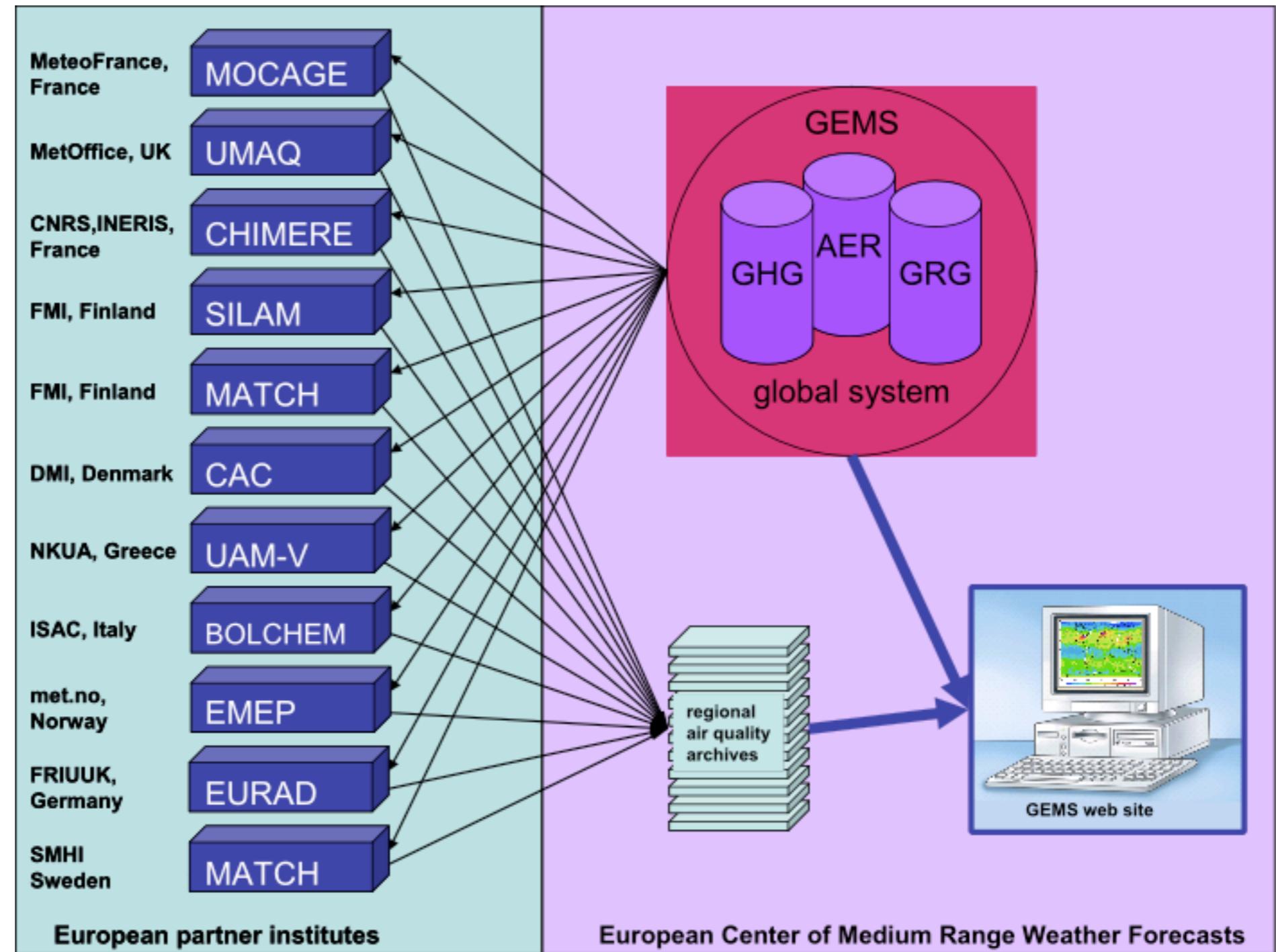
Sub-projects:

- Greenhouse gases
- Reactive gases
- Aerosols
- Regional air quality



GEMS project: Regional air quality

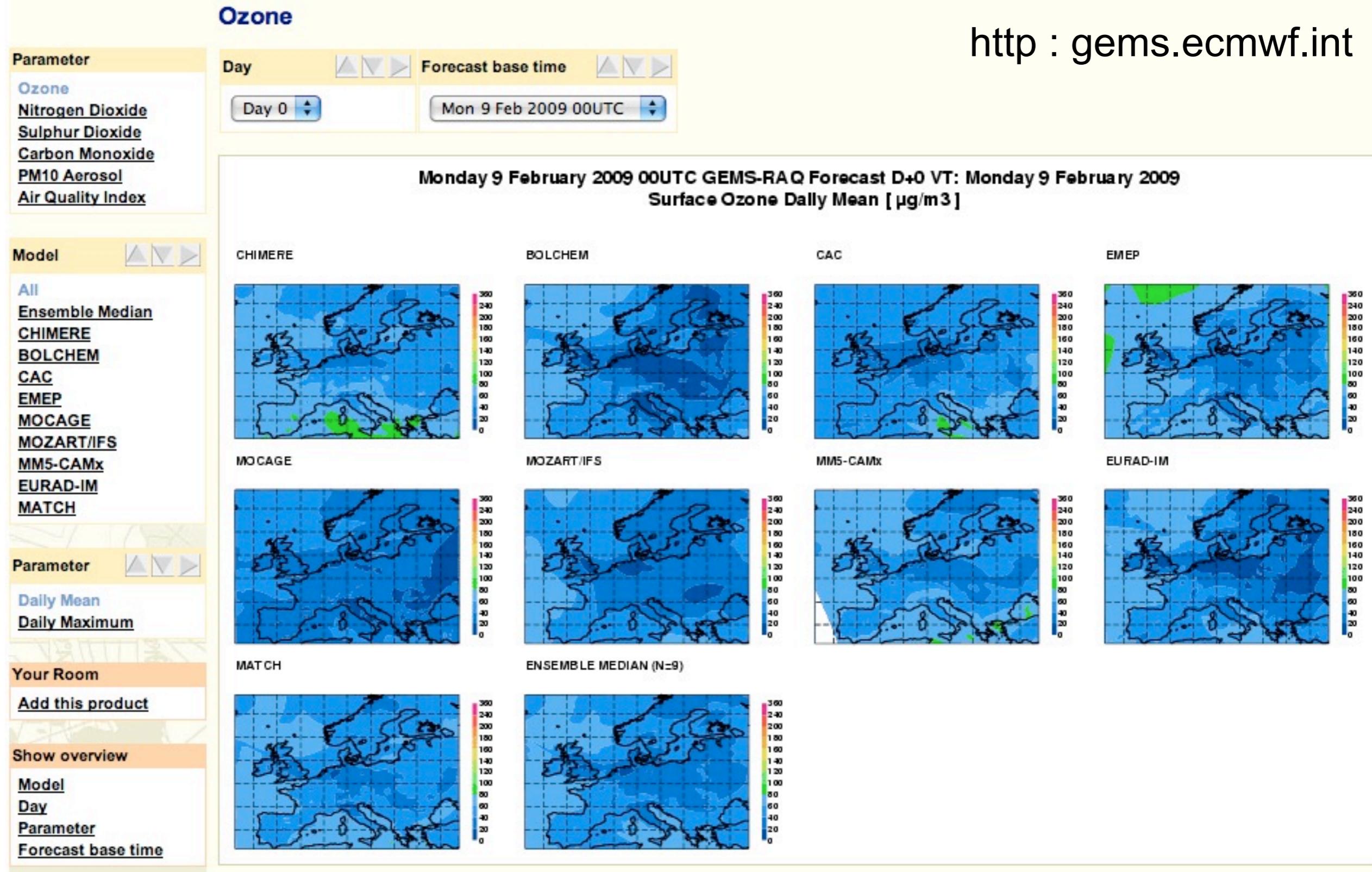
Air quality forecast for Europe,
based on an ensemble of (up to 11) models





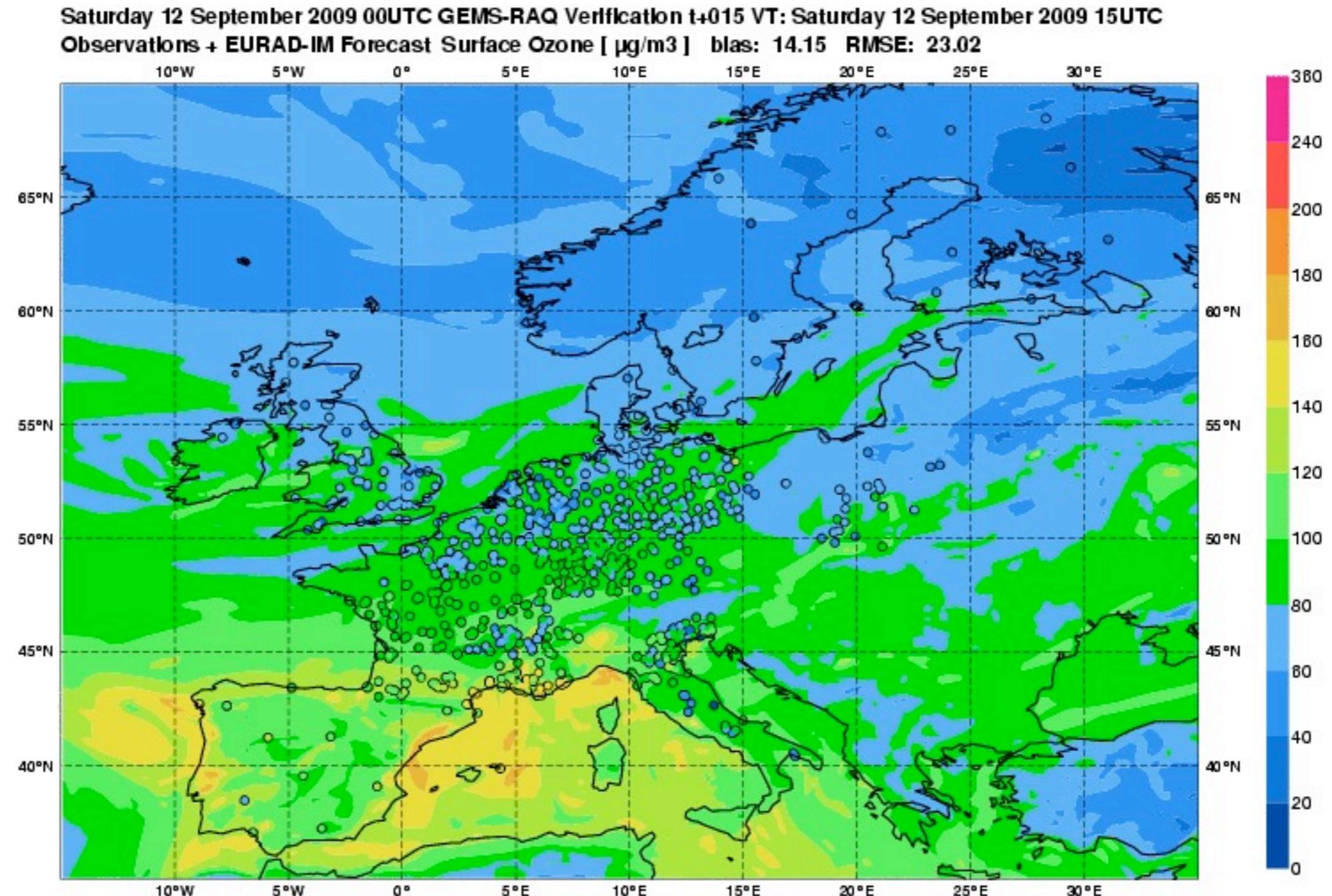
GEMS project: Regional air quality

[http : gems.ecmwf.int](http://gems.ecmwf.int)



GEMS project: Regional Air Quality

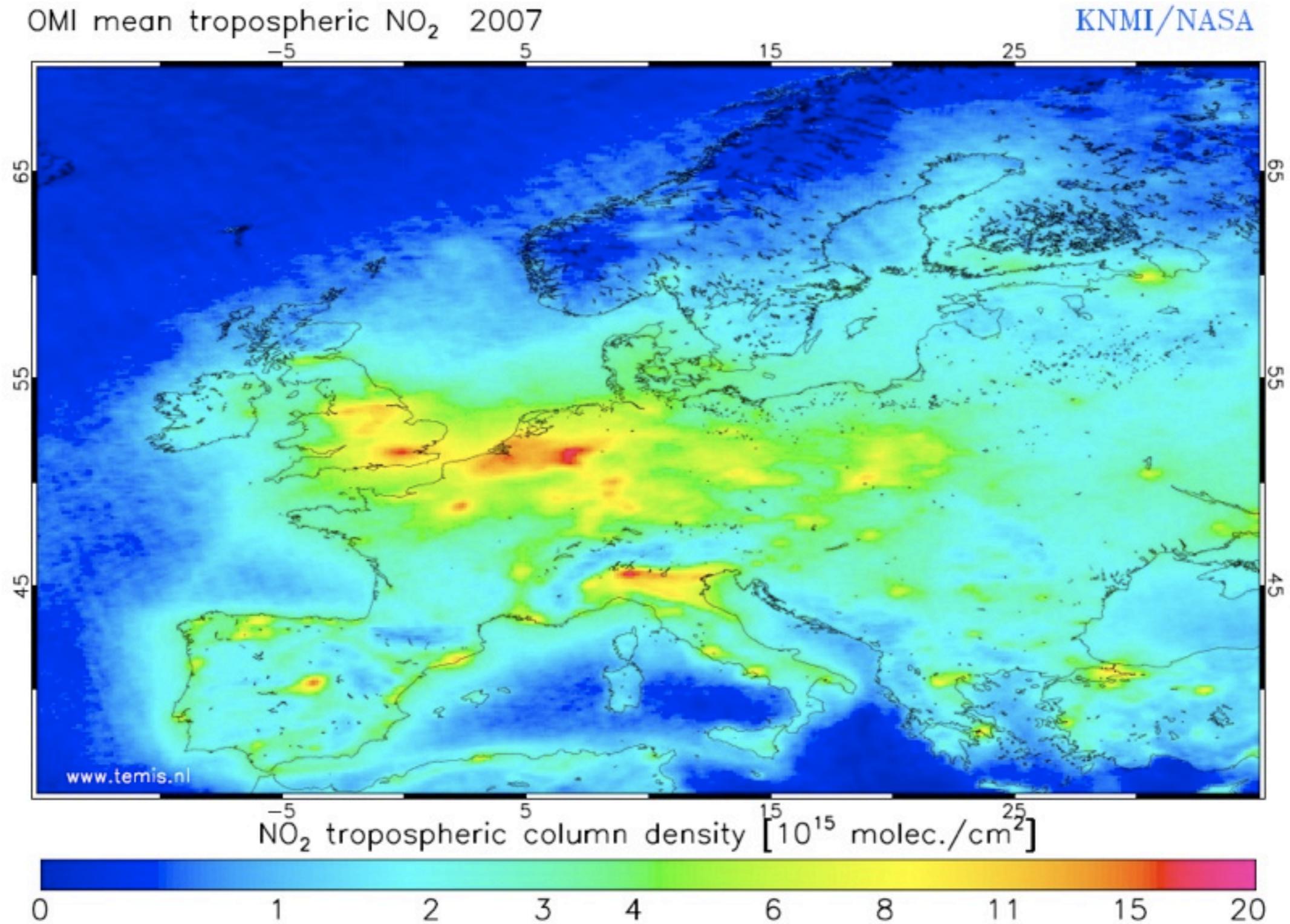
Verification with surface observations - near real time



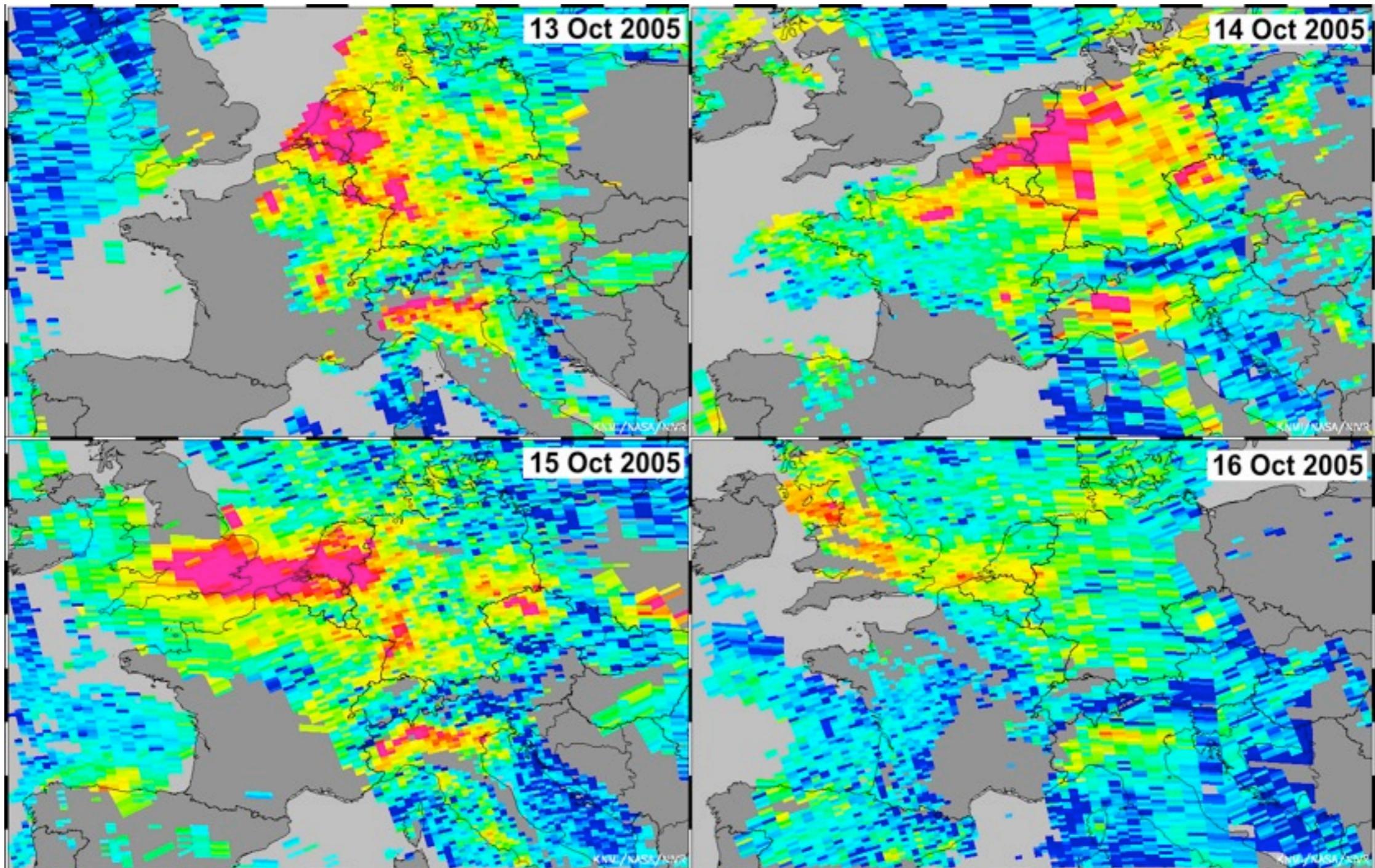
From GEMS website: <http://gems.ecmwf.int>



Satellite observations: OMI NO₂



OMI NO₂ - day-to-day variability

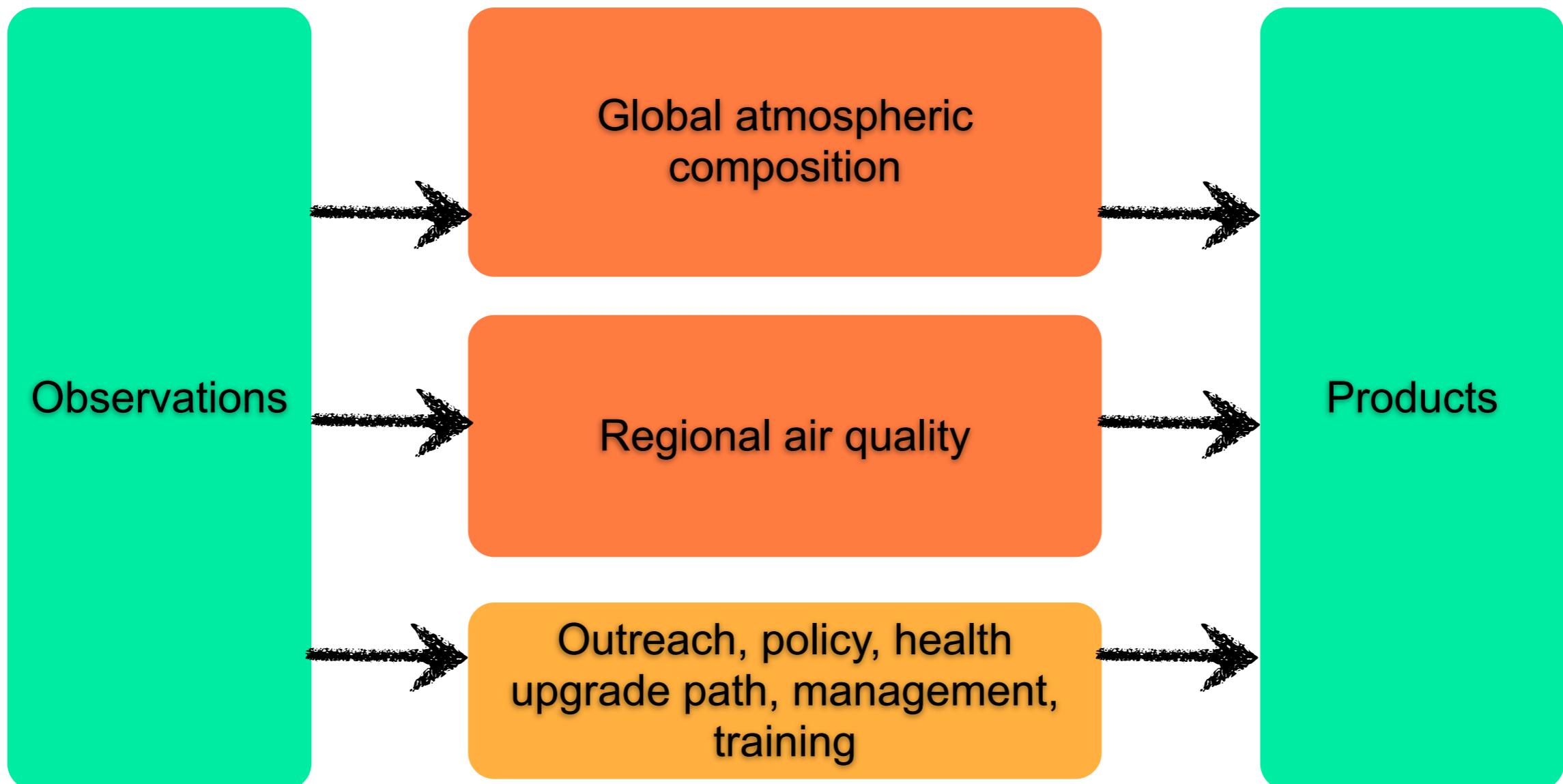


MACC project



Koninklijk Nederlands
Meteorologisch Instituut
Ministerie van Verkeer en Waterstaat

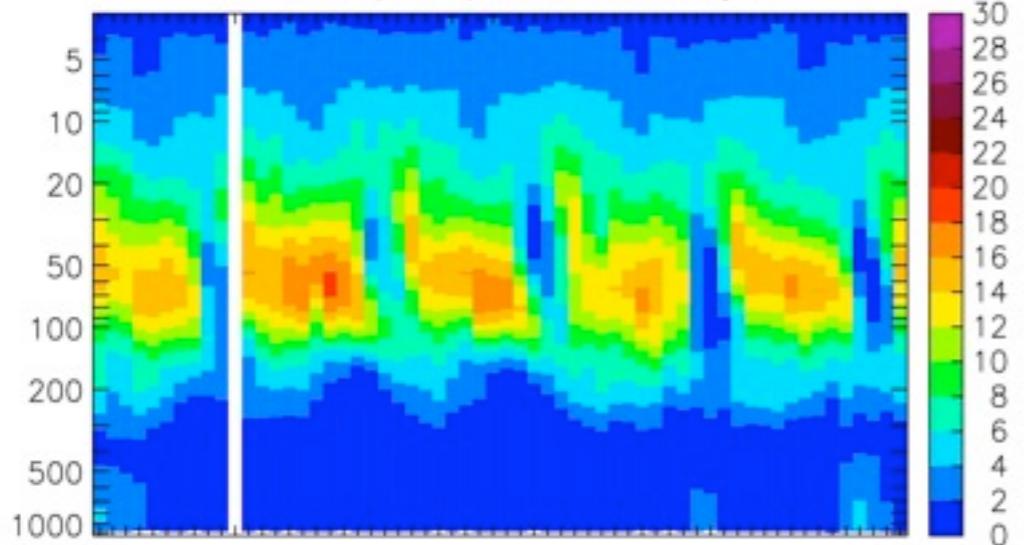
Precursor GMES Atmosphere Service (Continuation of GEMS and PROMOTE)
June 2009 - November 2012
Coordinator: ECMWF



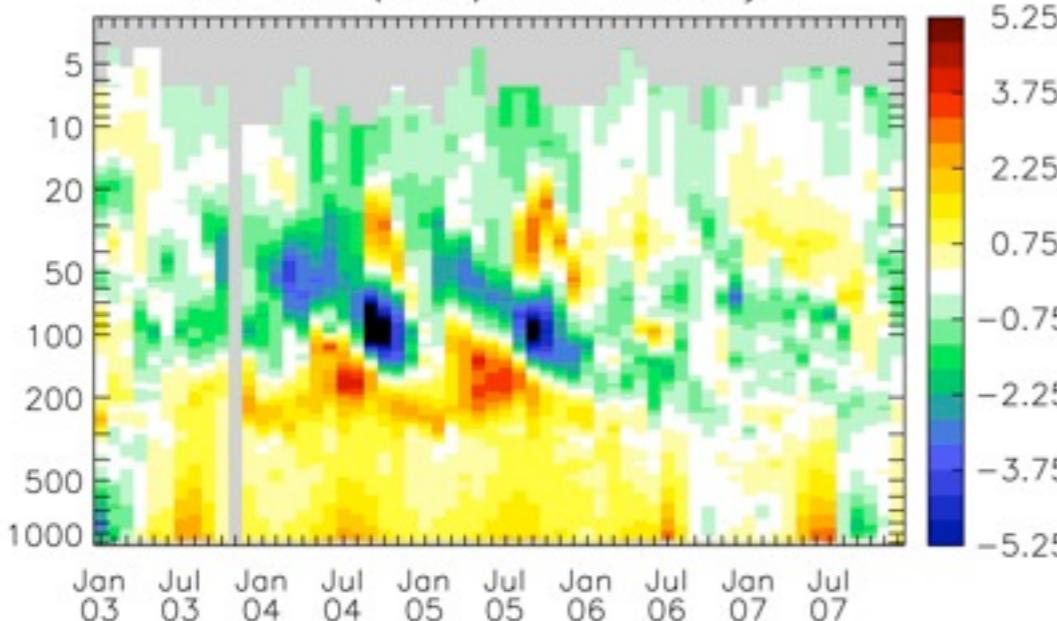
GEMS global reactive gases sub-project



Monthly mean analysis (f026) profiles of GO3 (mPa) over Neumayer



Monthly mean sonde-analysis (f026) profiles for GO3 (mPa) over Neumayer



MIPAS assimilation



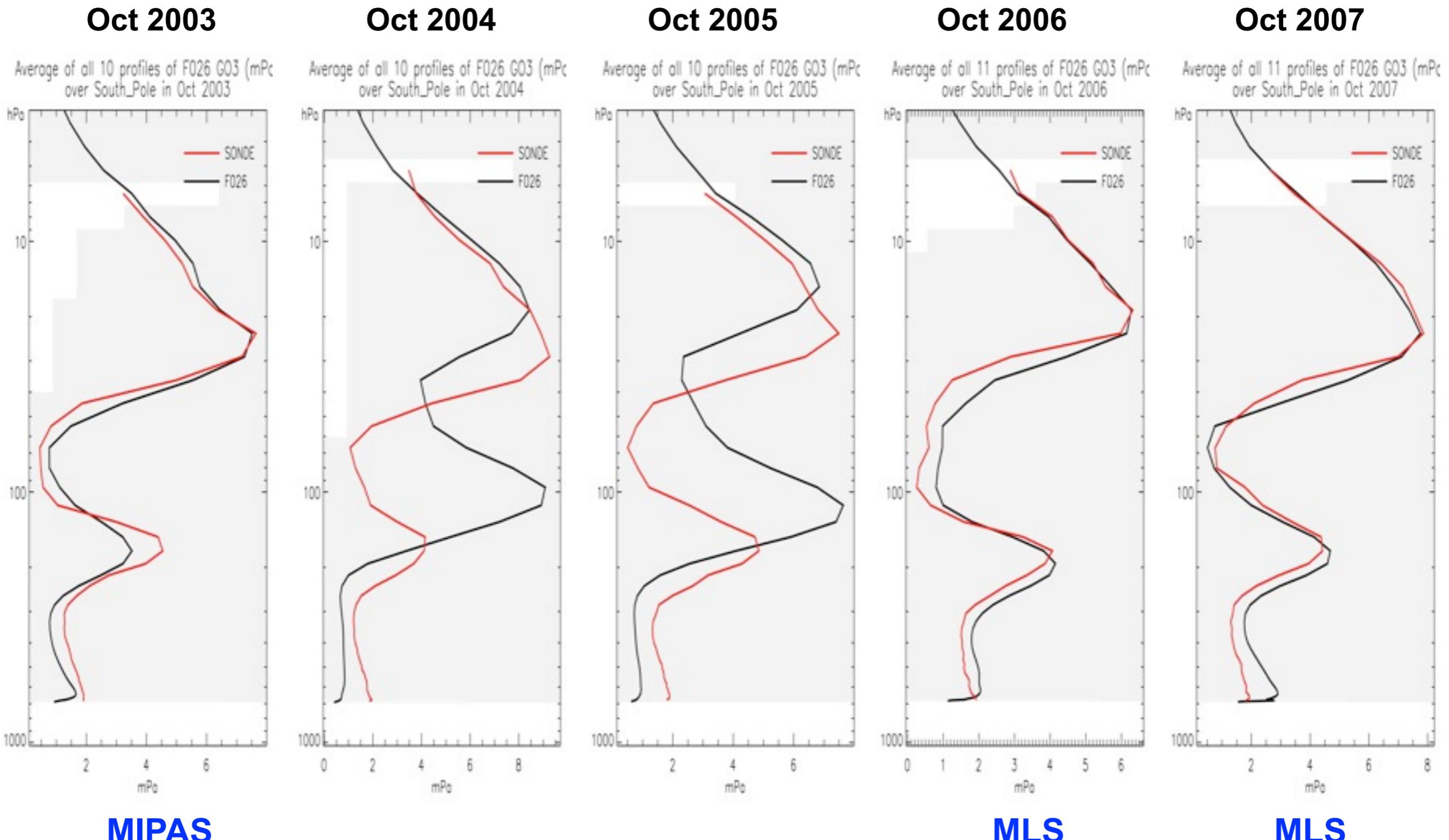
Begin of MLS assimilation



Source: Antje Inness, ECMWF

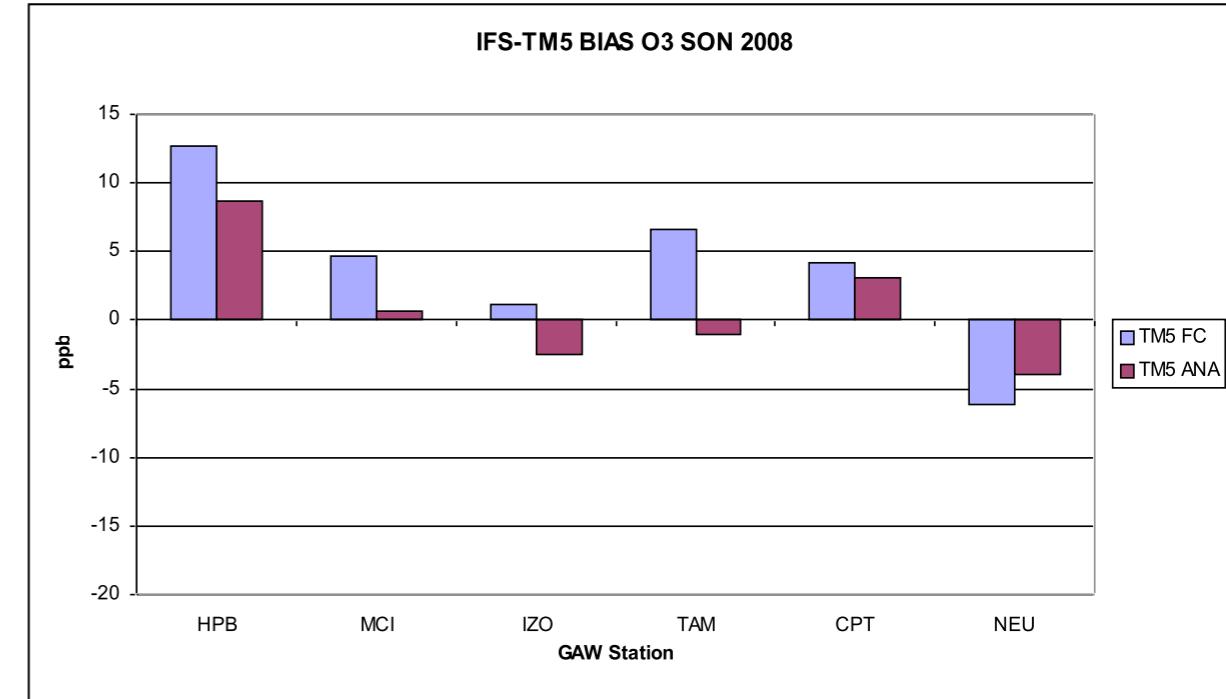
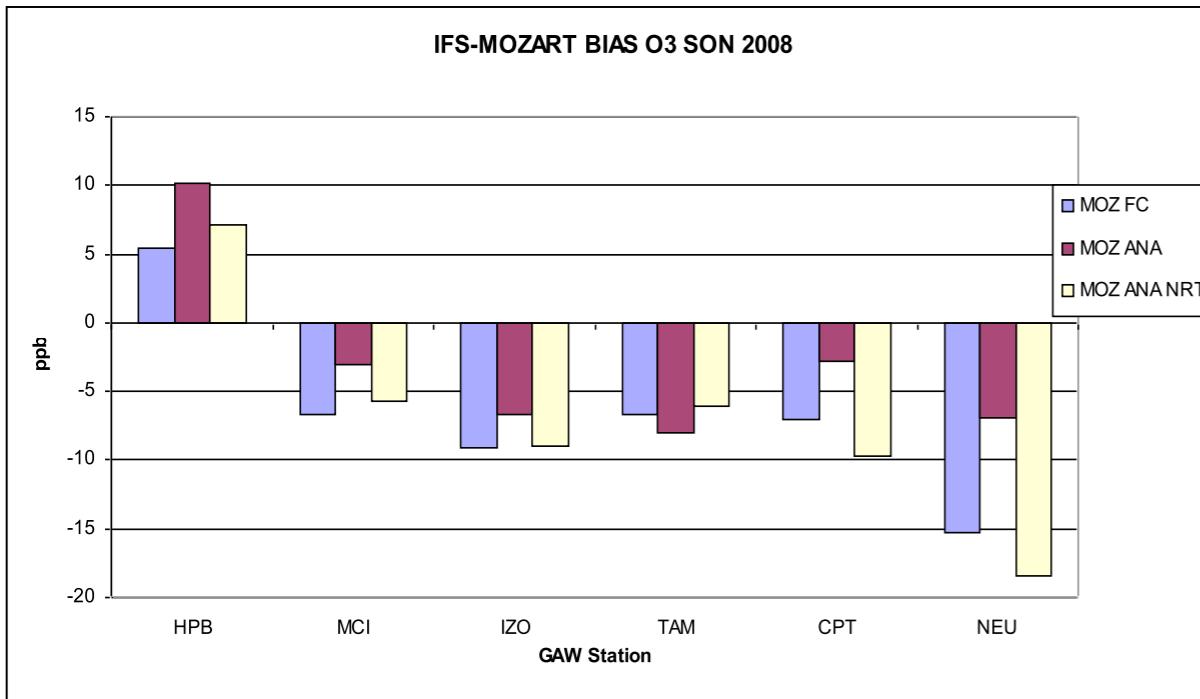
- Assimilation of ozone profile data (MLS, MIPAS) improves GEMS ozone analysis.
- Assimilation of OMI ozone columns and MLS ozone profiles leads to better agreement with sondes in troposphere.
- NRT MLS data are assimilated in MACC NRT analysis

South Pole O₃ profiles - GEMS reanalysis



Concl: Ozone profile data important for assimilation
Source: Antje Inness, ECMWF

O₃ analysis - GAW surface observations



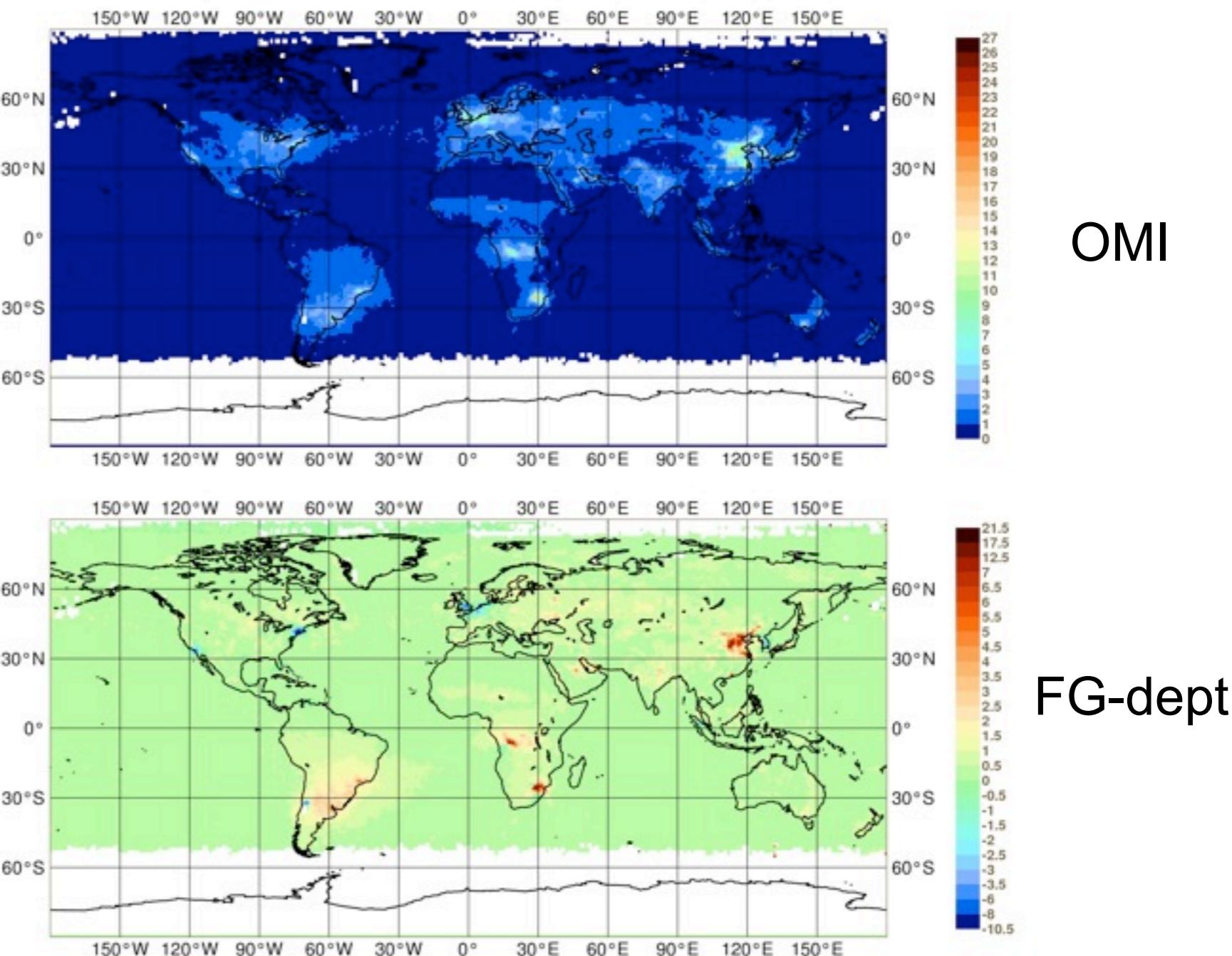
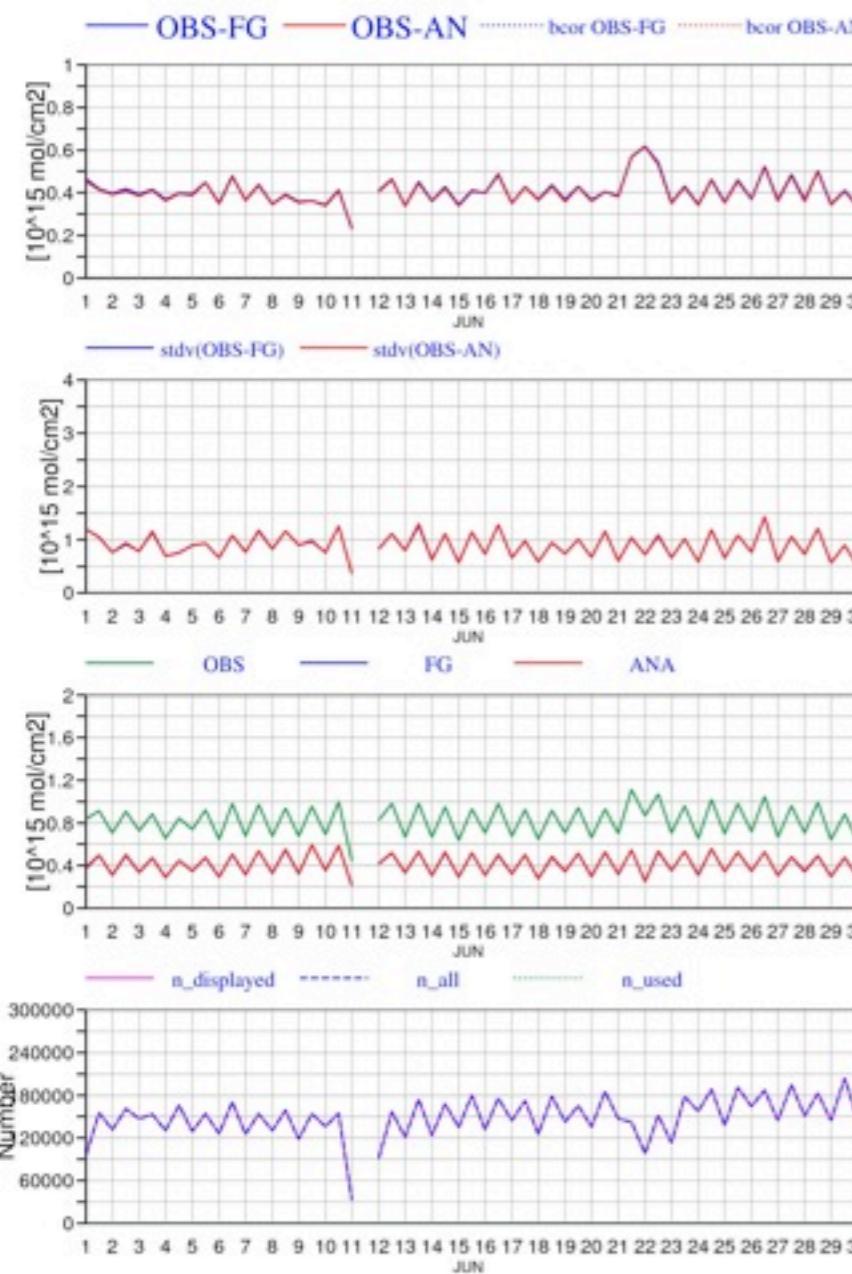
The dominance of stratospheric ozone and the small PBL signal make it difficult to improve ozone surface values by assimilation.

The multi-sensor-assimilation of OMI, SBUV, SCHIAMACHY and MLS improved surface values (ANA) both for the coupled system IFS-MOZART and IFS-TM5. However, when MLS profile data were not available (MOZ-ANA-NRT), the model result at the surface were not improved despite an improved total column values.

HPB Hohenpeissenberg
MCI Monte Cimone

IZO Izana
TAM Tamanrasset-Assekrem
CPT Cape Point
NEU Neumayer station

Monitoring of tropospheric NO₂ from OMI



OMI tropospheric NO₂ is compared against NO₂ from the MACC system (MOZART-IFS) and will be assimilated soon.
Source: Antje Inness, ECMWF



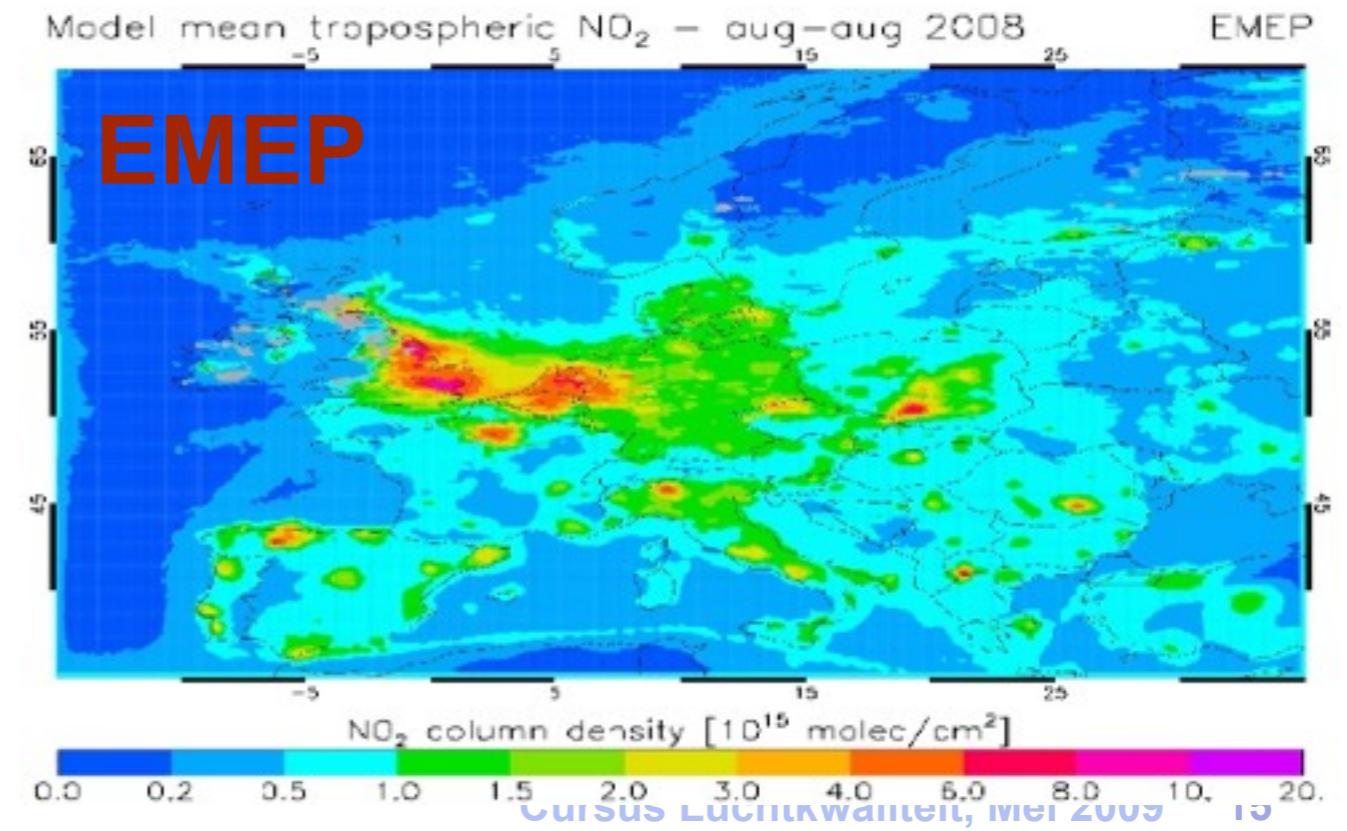
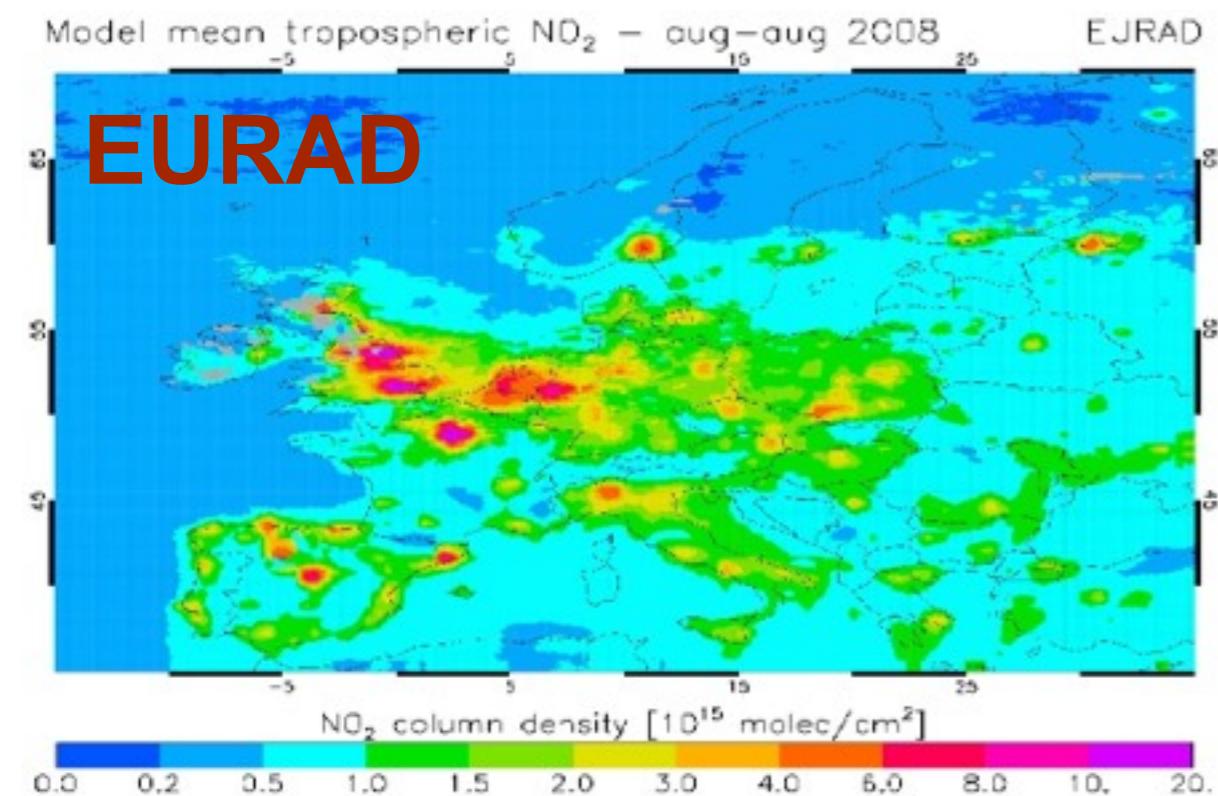
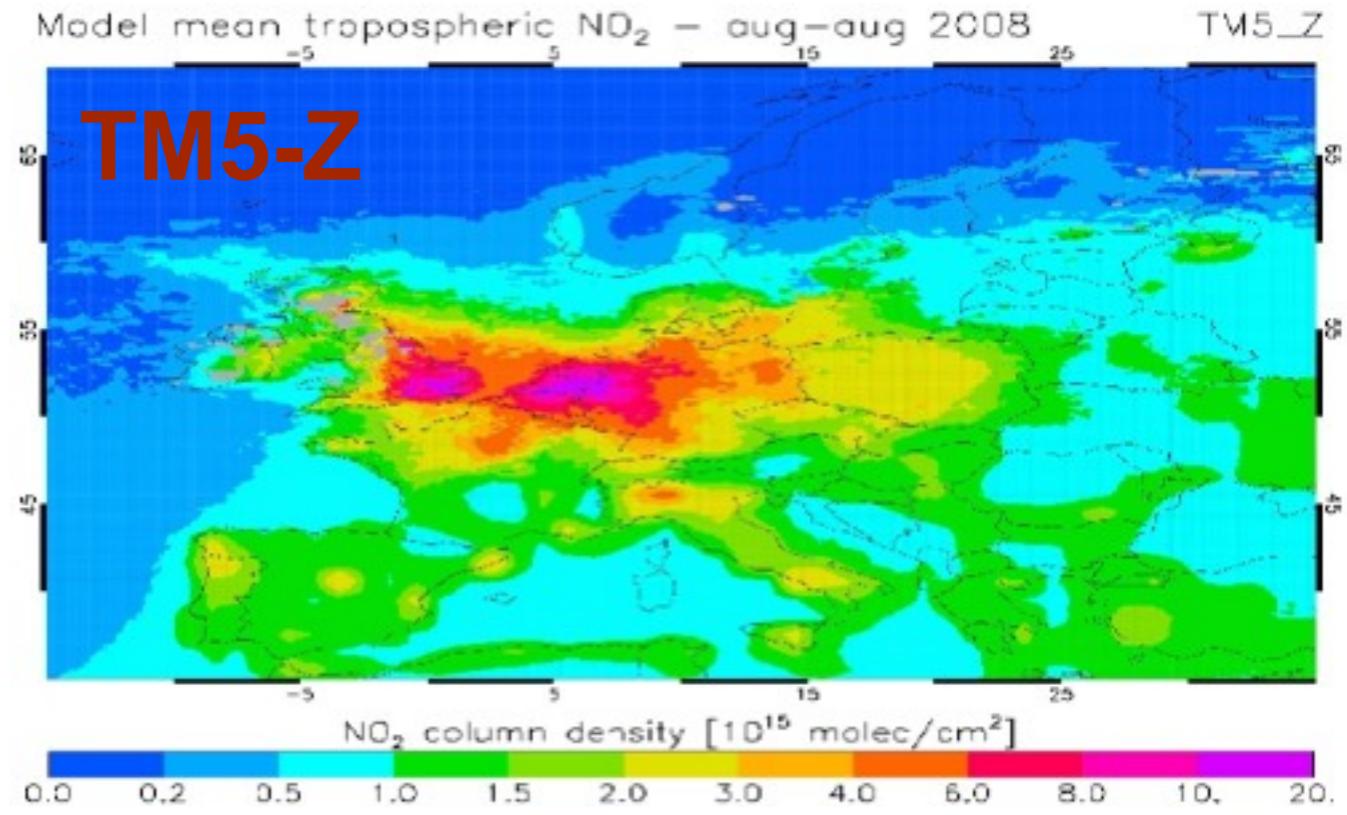
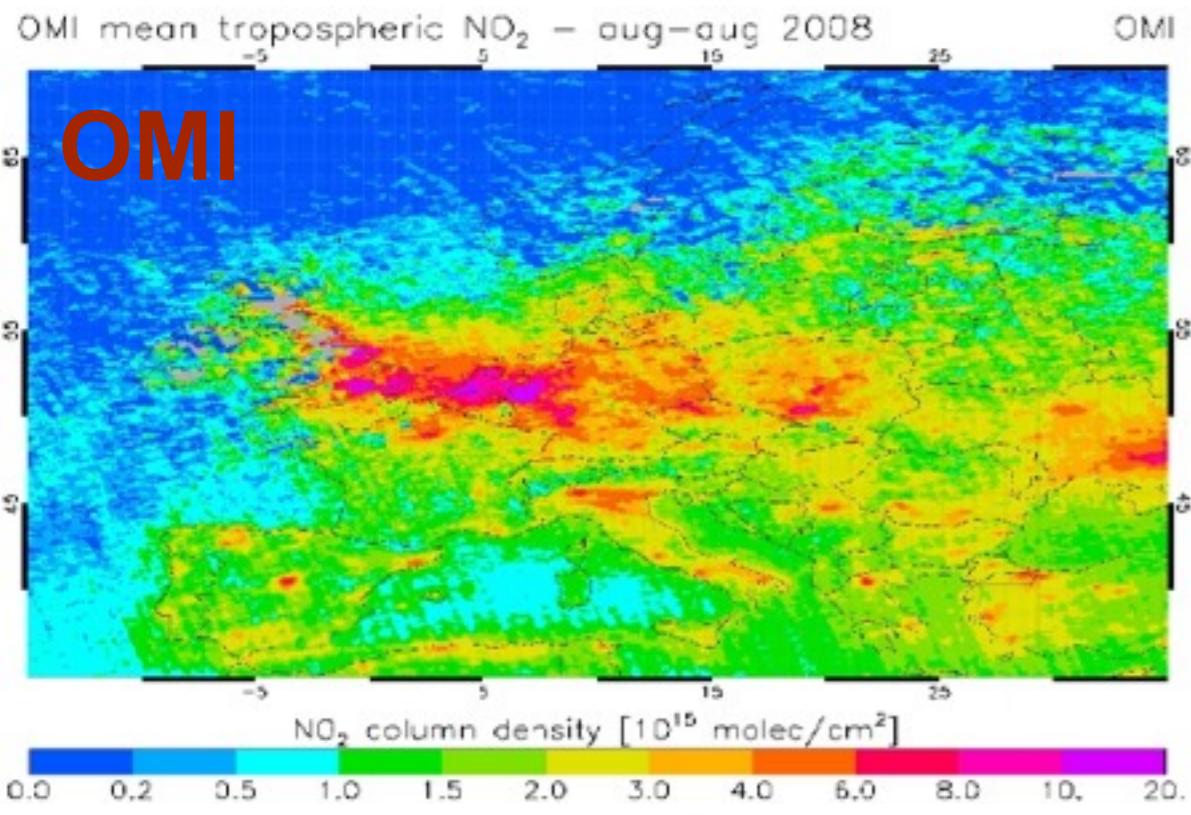
Comparison of modeled tropospheric NO₂ columns to OMI DOMINO product

- 8 regional models and 2 global models from GEMS project
- July 2008 – June 2009 over Europe
- Study differences between models
- Differences between models and OMI retrieval:
Effect of averaging kernels on modeled columns

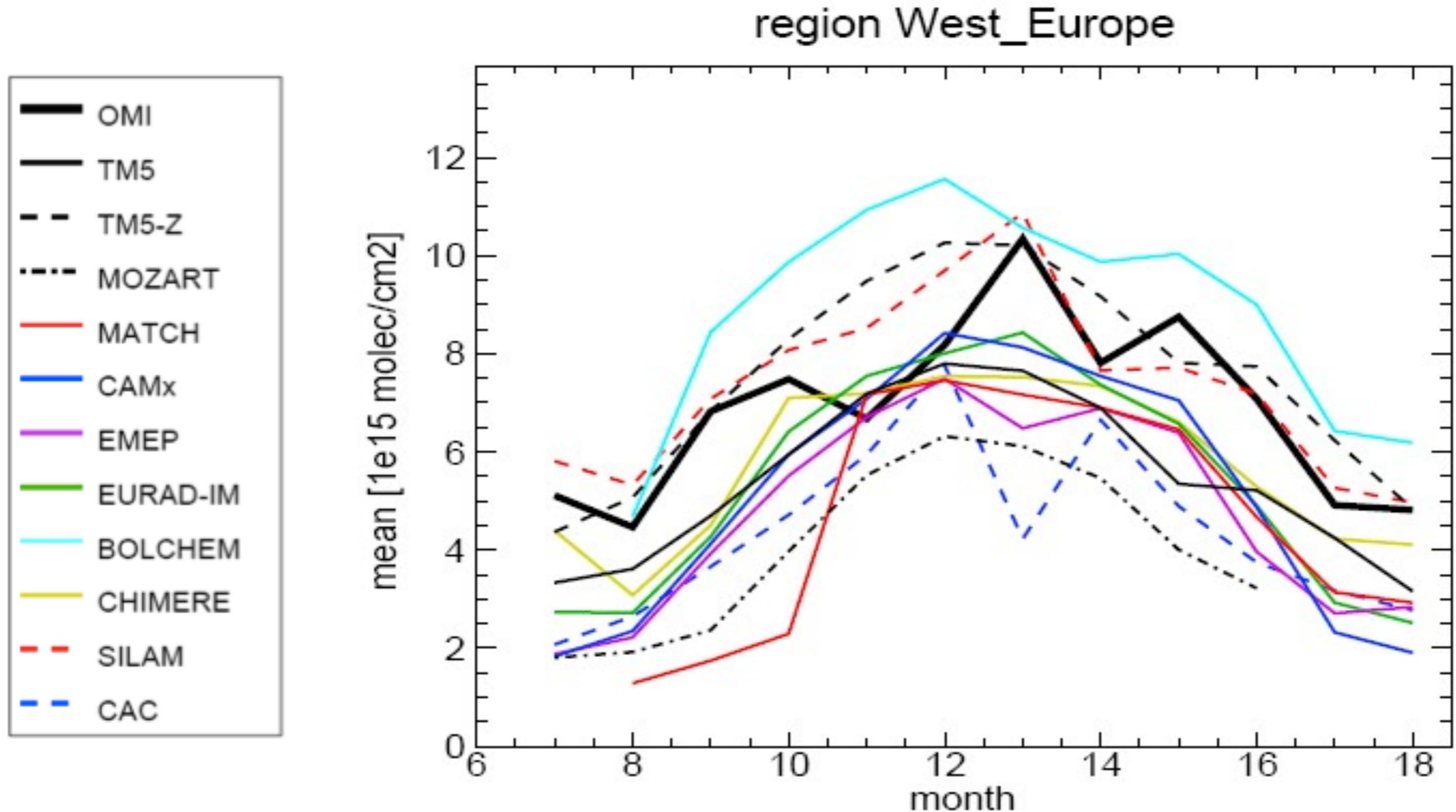
Source: Vincent Huijnen, KNMI



OMI vs models - August 2008

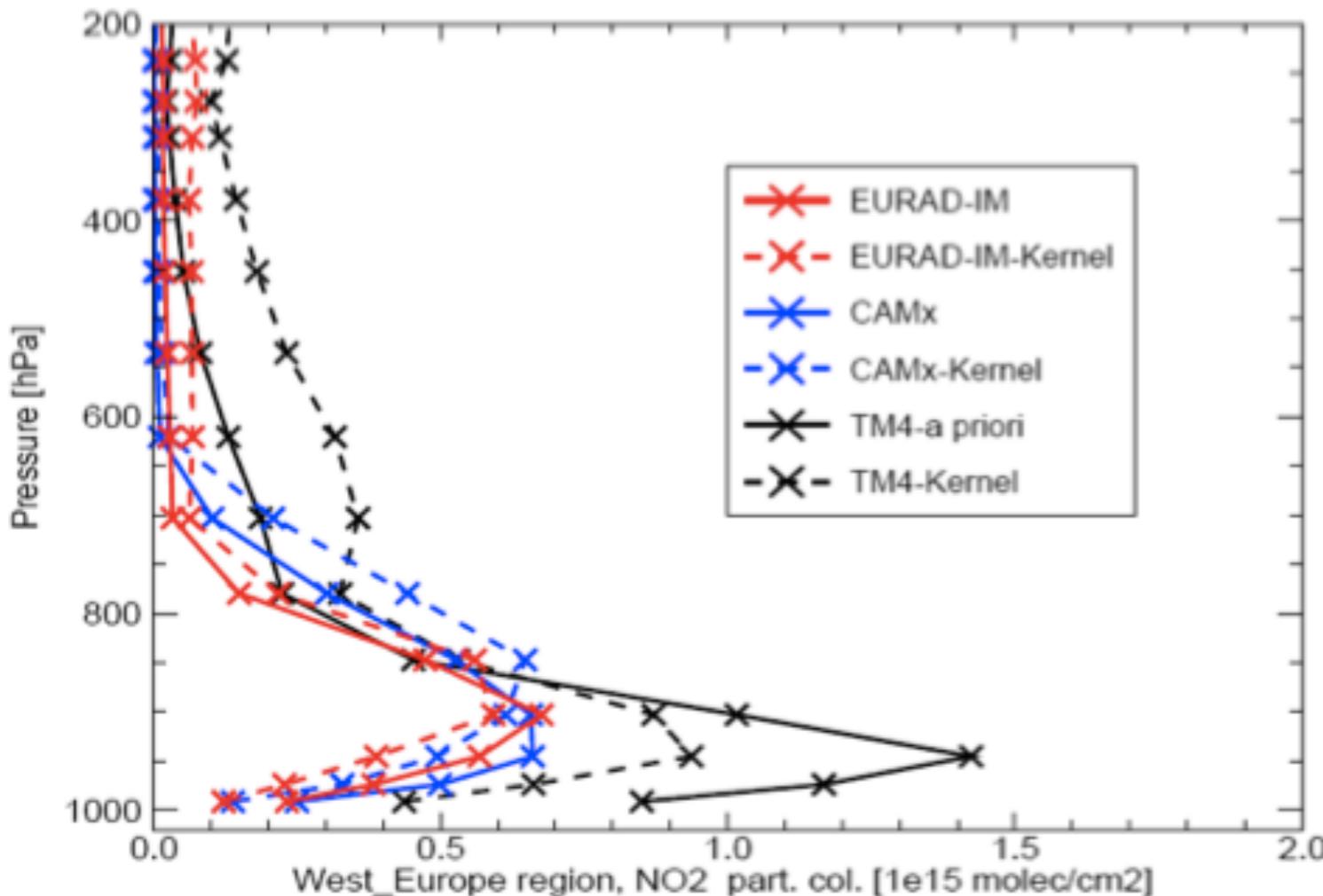


Seasonal cycle



Source: Vincent Huijnen, KNMI

Effect of averaging kernel on modelled column (August 2008)

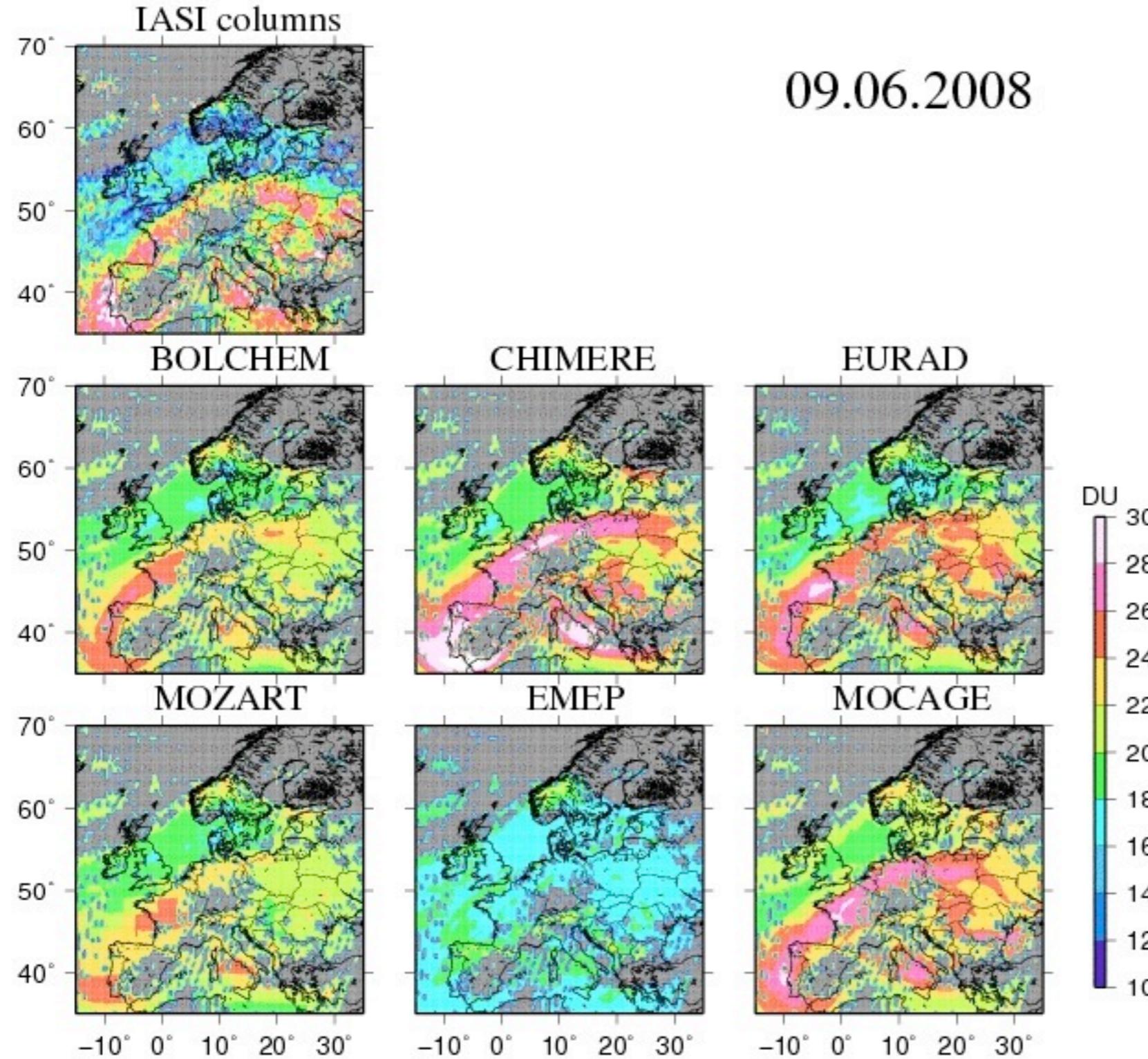


N_tc/N_ak	PBL	FT	Total
TM4	4.8/3.6	1.0/2.2	5.8/5.8
EURAD-IM	2.3/1.9	0.4/0.9	2.7/2.8
CAMx	2.3/1.8	0.3/0.5	2.6/2.3

Source: Vincent Huijnen, KNMI



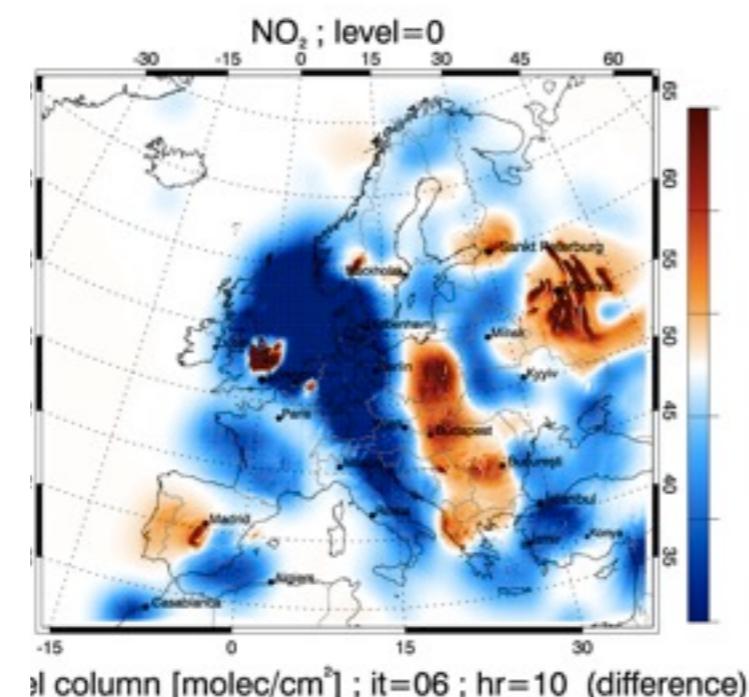
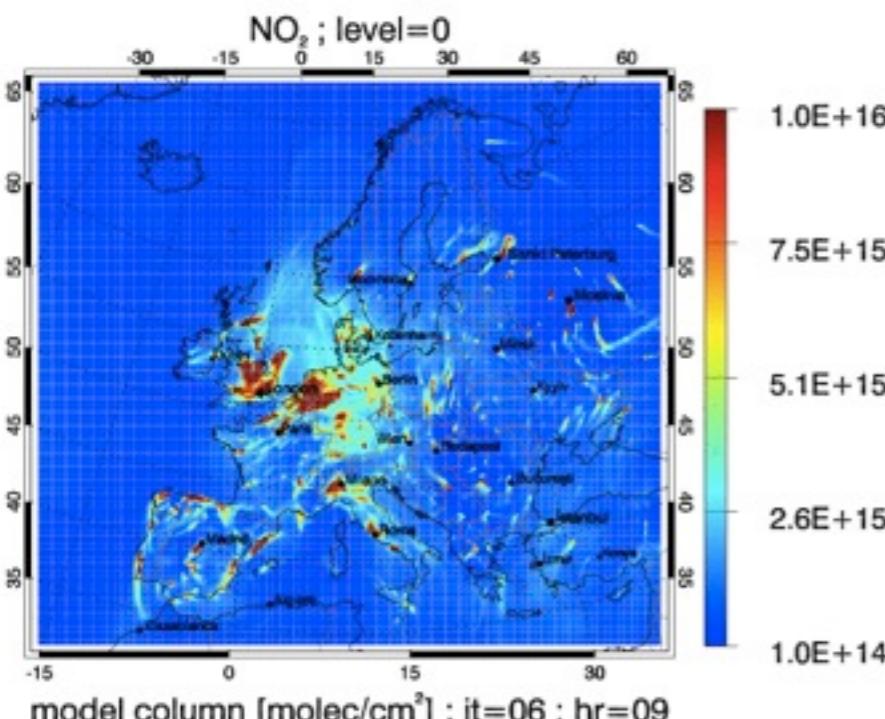
Comparison IASI tropospheric ozone with GEMS-RAQ models



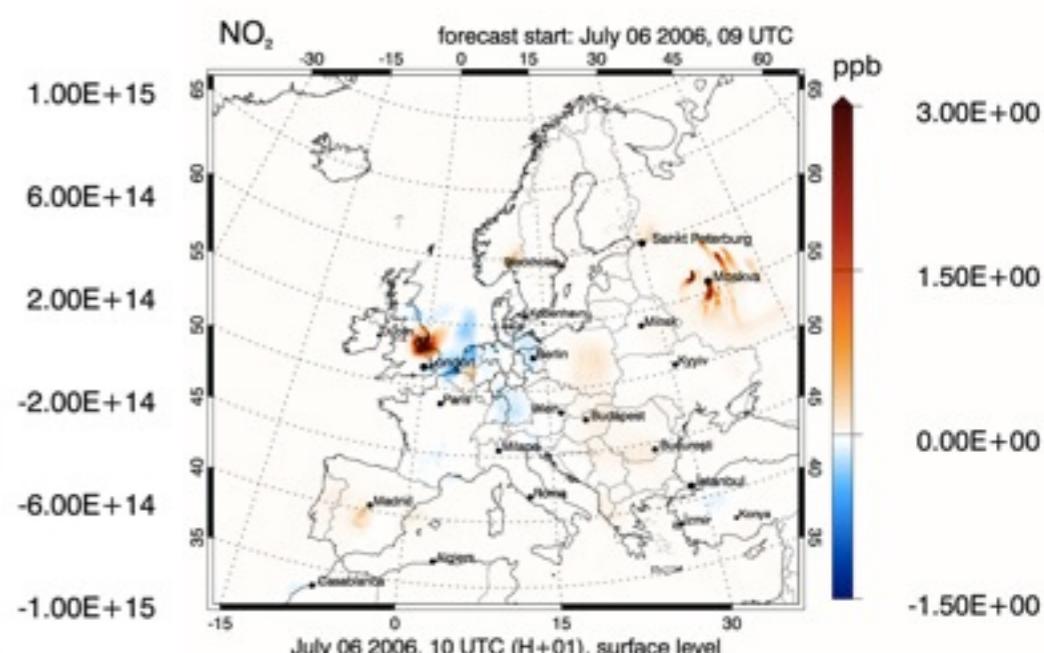
Source:
Matthias Beekmann,
LISA, CNRS
Eremenko et al,
GRL 2008

Data assimilation result from tropospheric columns for July 6th, 2006.

NO₂ model columns by OMI and SCIAMACHY assimilation with EURAD, interval 09-12 UTC.



molecules/cm²



NO₂ ppb

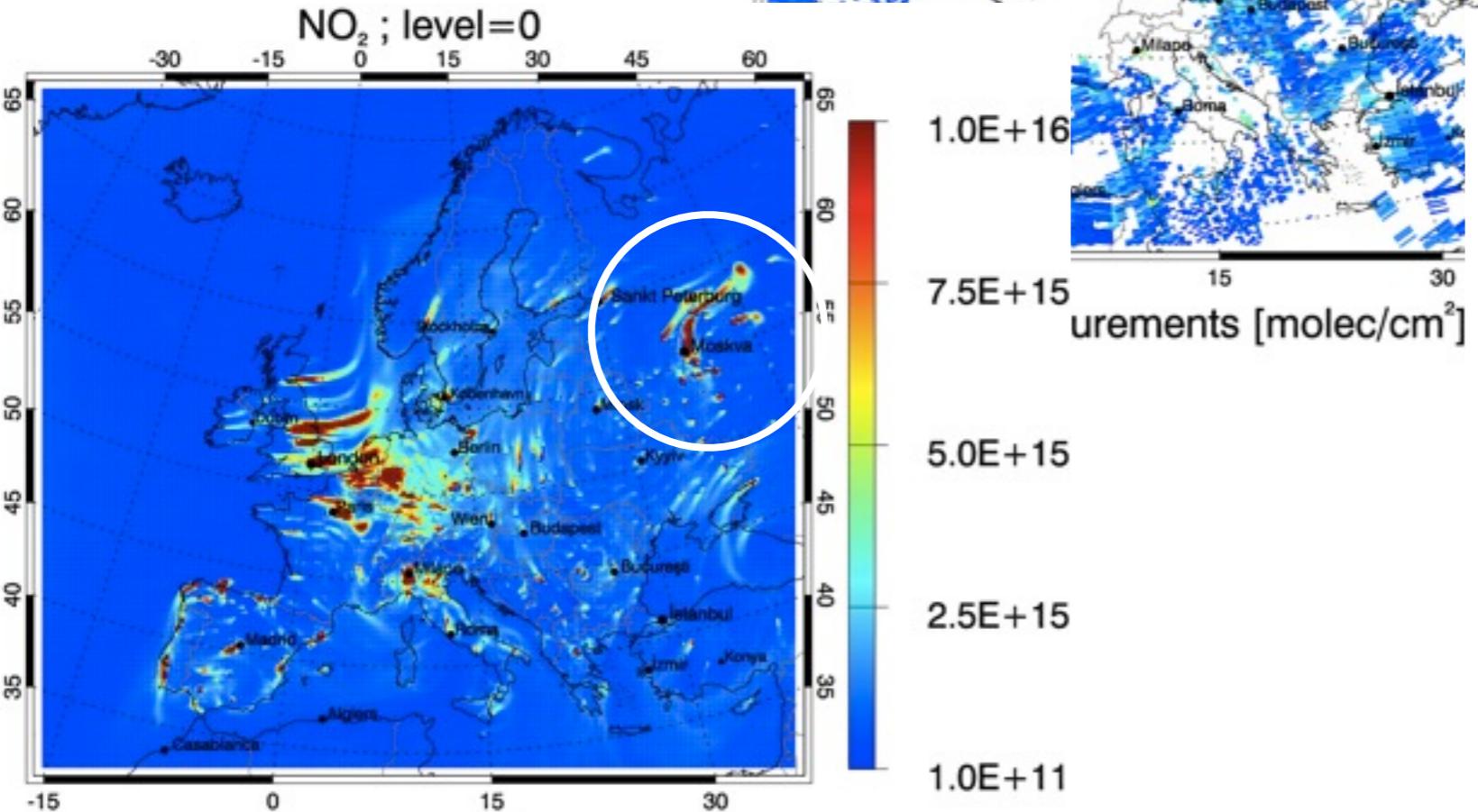
Analysed NO₂ colum | Difference field | surface concentration changes

Source: Hendrik Elbern, Univ. Cologne (EURAD group)

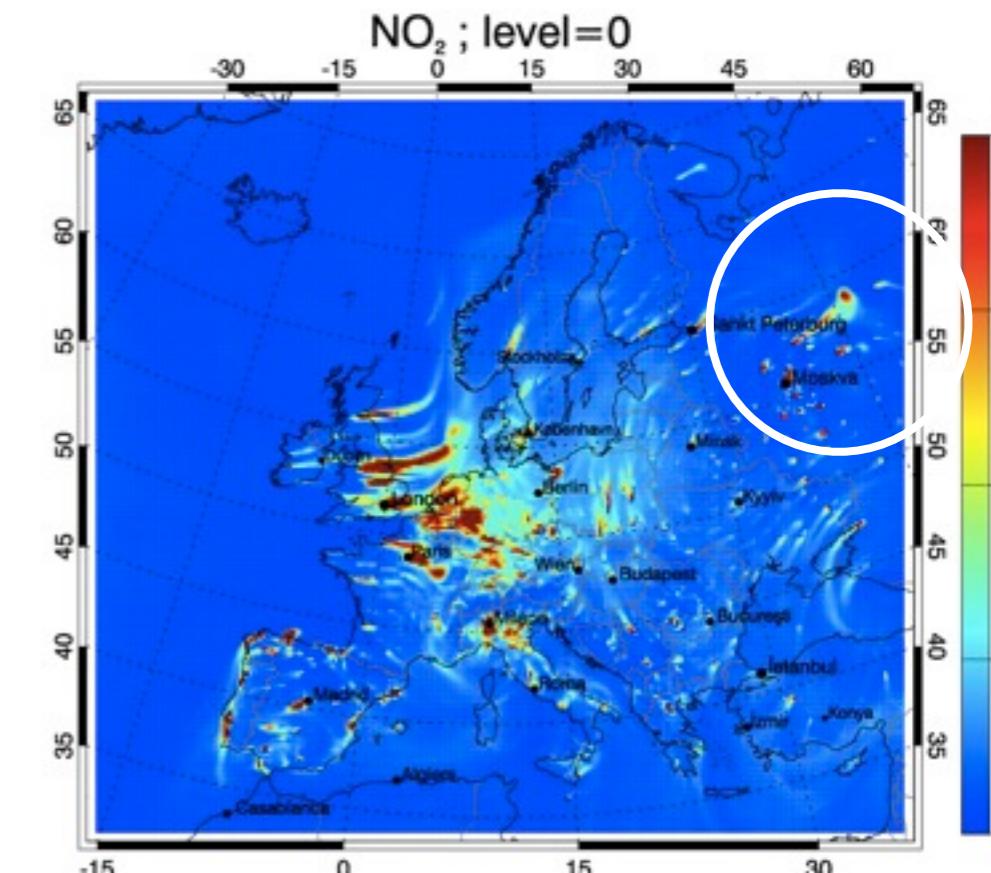
Data assimilation result from tropospheric columns for July 7th, 2006.

Source: Hendrik Elbern, Univ. Cologne (EURAD group)

pure forecast



assimilation
based
forecast



Assimilation OMI NO₂ with Lotos-Euros

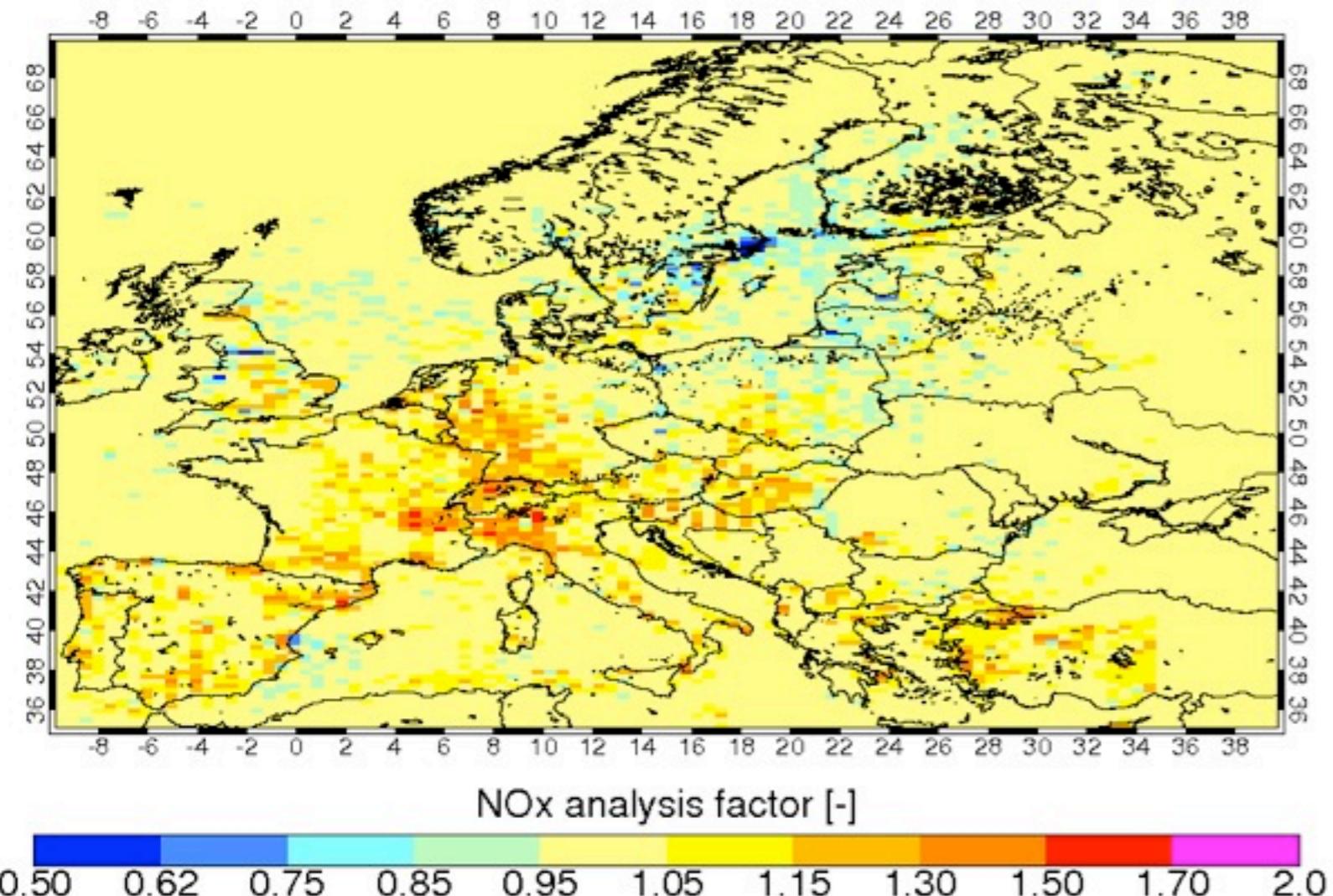


Koninklijk Nederlands
Meteorologisch Instituut
Ministerie van Verkeer en Waterstaat

Assimilation OMI NO₂ observations with
regional AQ model LOTOS-EUROS

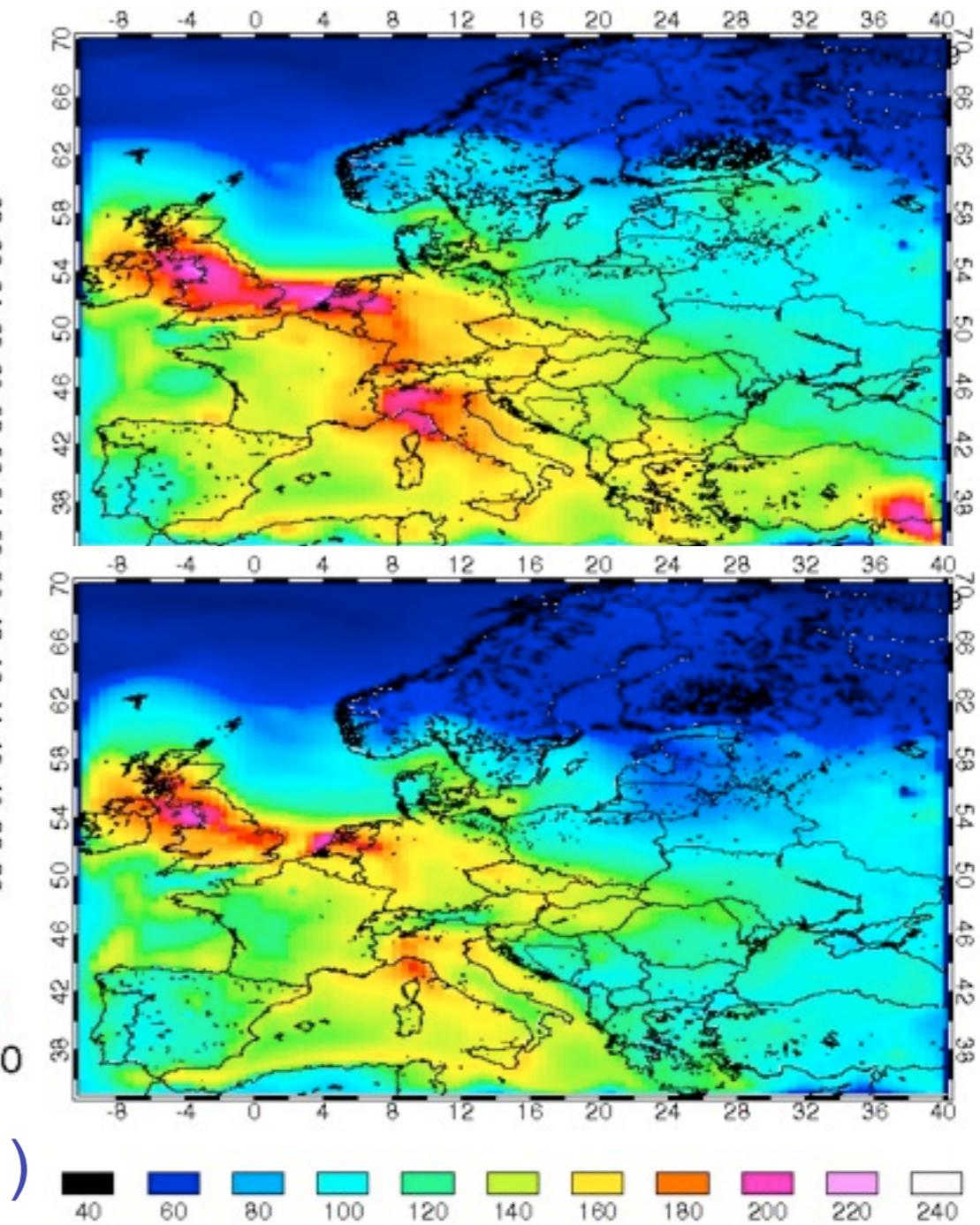
Lotos-Euros, date 20060717

KNMI/RIVM/TNO



Analysed NO_x emission / inventory (yellow=1)

Impact ozone at the surface





Conclusions

GEMS / MACC

- Major European effort to assimilate and forecast atmospheric composition on the global and regional scale
- Near-real time availability of data crucial.

Ozone

- Availability of profile information (and kernel information) very important

NO₂

- OMI is a big step forward for NO₂ tropospheric column assimilation (coverage, resolution),
- 4D-var able to assimilate, while retaining NO₂-NO chemical balance,
- Uncertainty (error bar) of the measurements is large, and impact of measurements often small. Improvement of retrieval quality important.
- Impact on the surface: The averaging kernel shape remains critical; impact dependent on the assimilation setup
- Overall results for OMI/SCIAMACHY NO₂ are encouraging, but far from mature to provide Best Linear Unbiased Estimates of emission



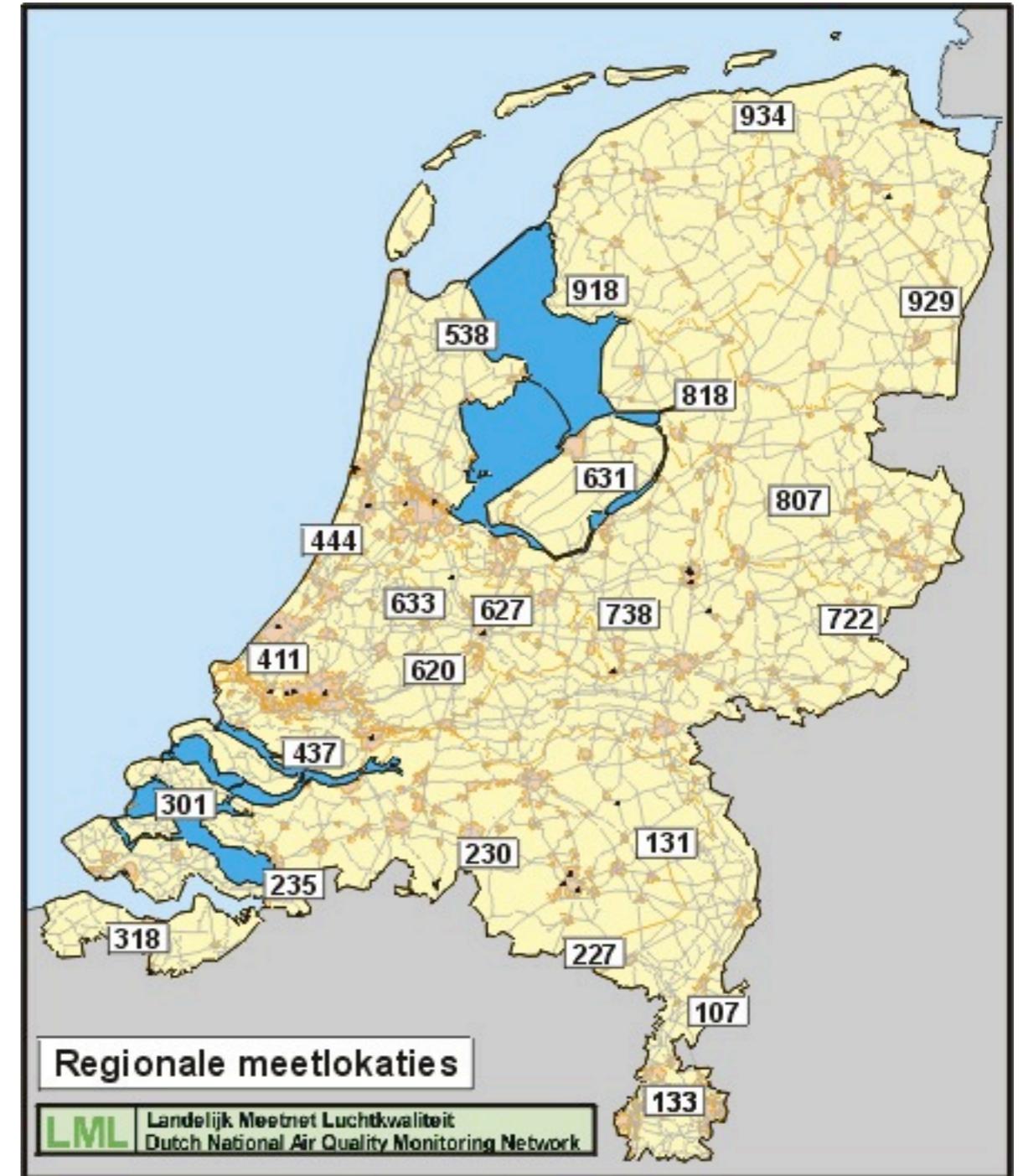
Spare sheets



Metingen aan de grond

RIVM LML stations
type “regionaal”

Uurlijkse metingen van
Ozon, PM10, NO2, SO2,



Verwachtingen luchtkwaliteit Nederland

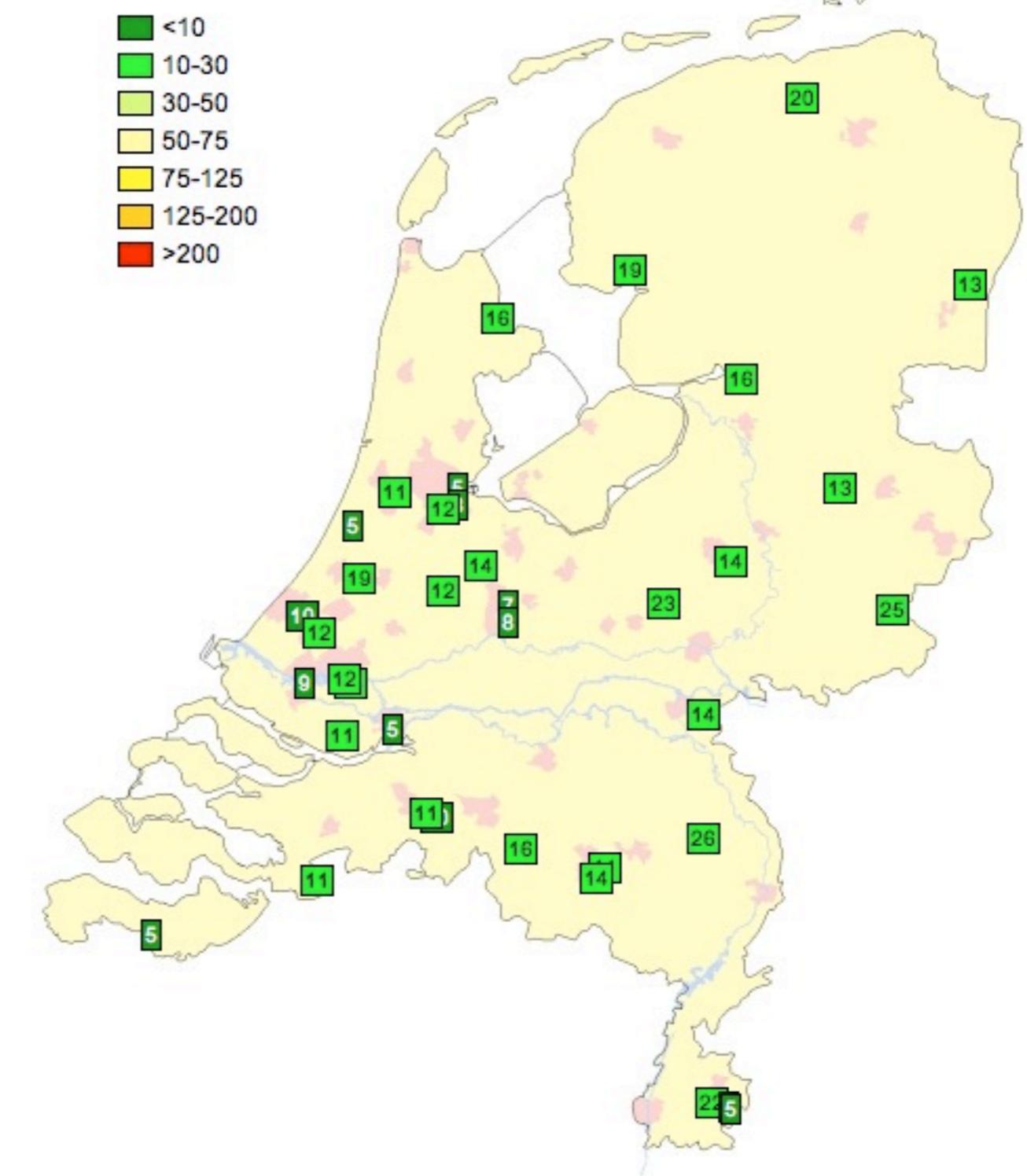


Koninklijk Nederlands
Meteorologisch Instituut
Ministerie van Verkeer en Waterstaat

LML statistische verwachtingen (ozon en PM10)

Op basis van metingen van
gisteren en meteorologische
indicatoren, e.g. verandering in
temperatuur

Nieuwe ontwikkeling:
Prognostische modellen
(Lotos-Euros)



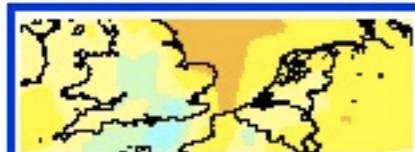


SmogProg project, GO programma, NIVR, 2007-2008

- Doel: Vervangen van (simpel) statistische LK verwachting van RIVM
- Samenwerking drie instituten: RIVM, KNMI, TNO
- Gebaseerd op LOTOS-EUROS model (en Franse CHIMERE model)
- Regio: Nederland en omringende landen (ongeveer 15 km resolutie)
- Assimilatie van meetnet gegevens en satelliet gegevens
(NO₂ van OMI op EOS-Aura)
- Focus op ozon en precursors

Operationalisering

- KNMI project, januari-meい 2009



SMOG FORECAST NETHERLANDS

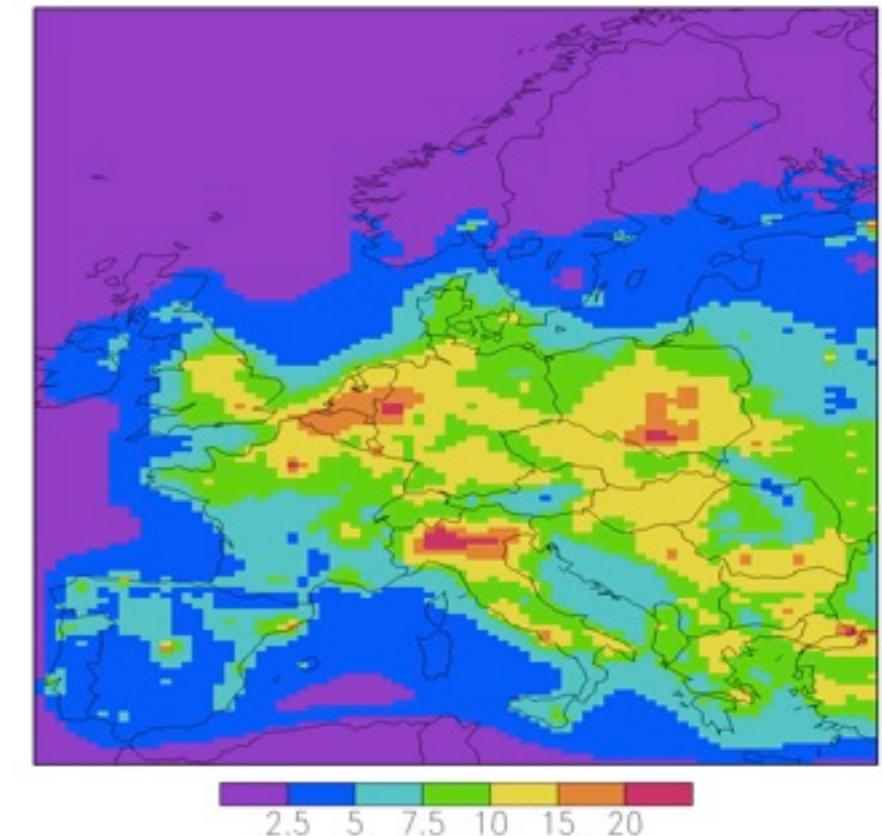
rivm



Lotos-Euros model

Nederlands model:

- LOTOS ontwikkeld door TNO
- EUROS ontwikkeld door RIVM

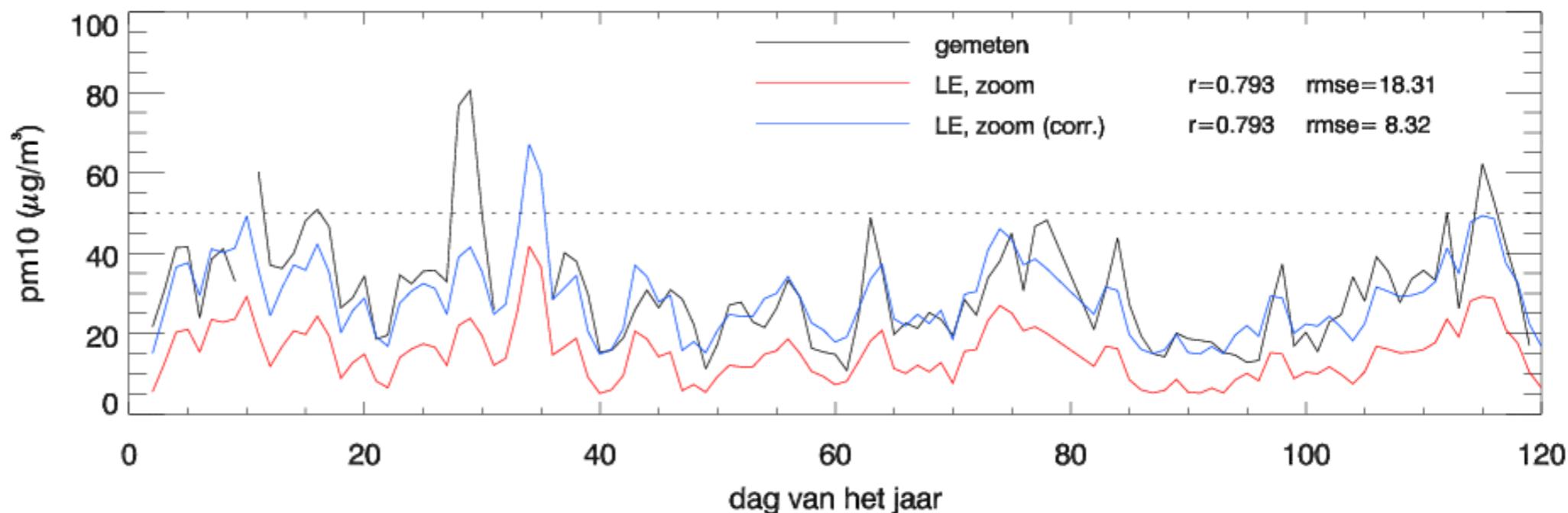
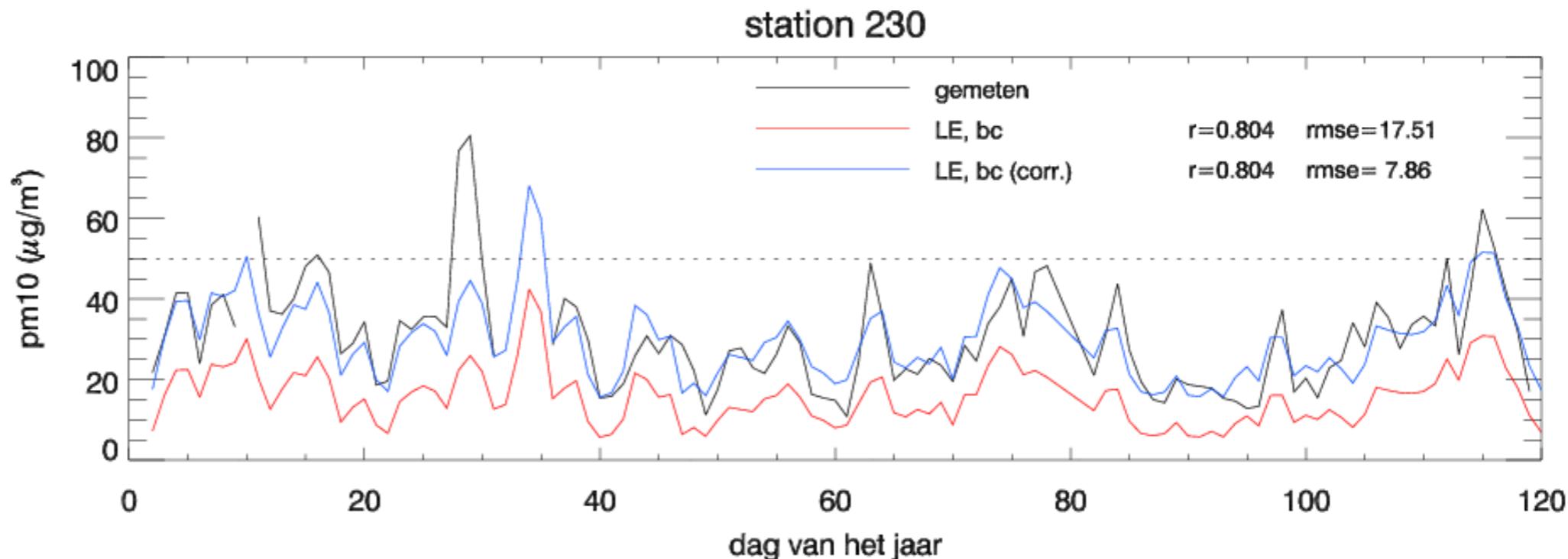


Model ingrediënten:

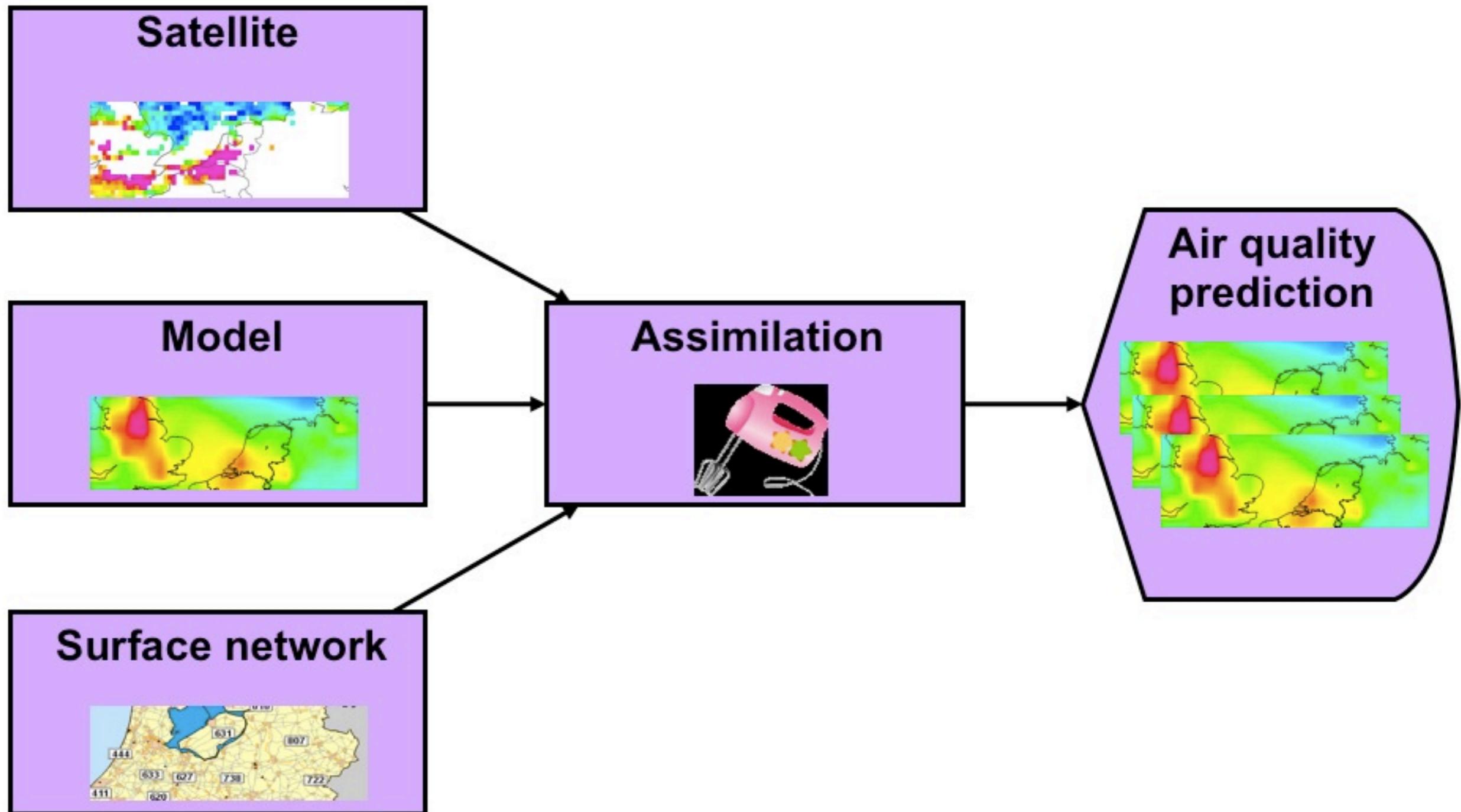
- Ozon en precursor gassen, aerosol, zware metalen, POP
- Europees domein, 0.5x0.25 graad (lon-lat)
- Zoom domeinen, e.g. 0.25x0.125 graad (lon-lat)
- Dynamische grenslaag (4 lagen, top bij 3.5 km)
- ECMWF analyses/verwachtingen (FU Berlin, HIRLAM/RACMO)
- Natte/droge depositie, emissies, transport, verticale uitwisseling
- Gasfase chemie: CBM-IV
- Aerosol: fijn/grof, SO₄, NO₃, NH₄, EC, OC, zeezout

Fijn stof: Model vs LML station Biest-Houtakker

Januari-April



Data assimilatie





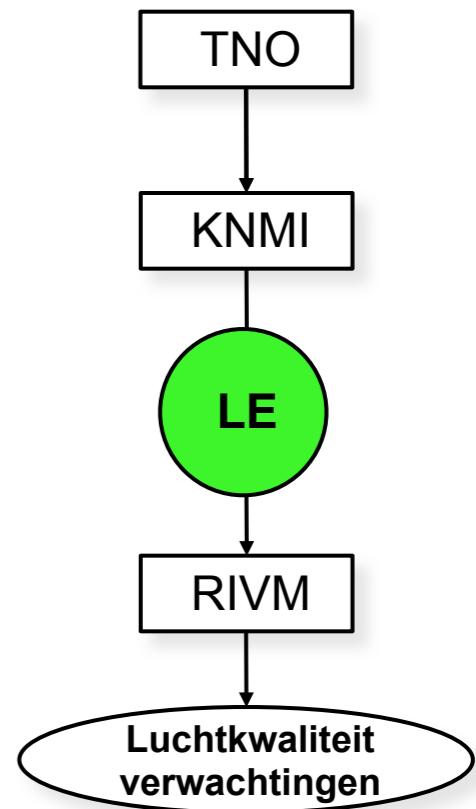
LuKwa project: betrokken partijen

RIVM

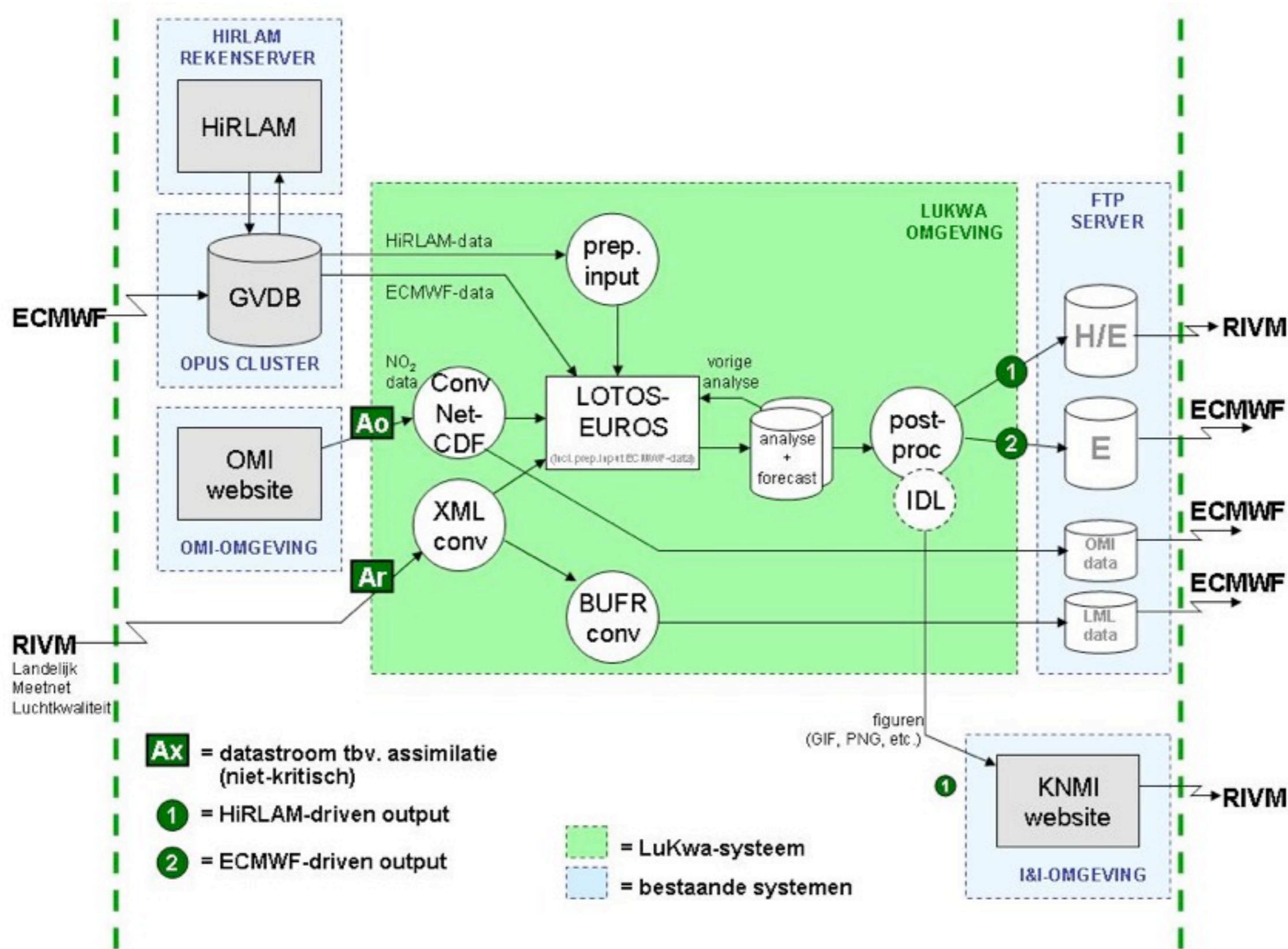
heeft als wettelijke taak om de Nederlandse bevolking te informeren over de huidige mate van luchtkwaliteit en de verwachting van luchtkwaliteit voor morgen.

TNO

Lotos-Euros software wordt ontwikkeld in een samenwerking tussen TNO, RIVM, KNMI



LuKwa omgeving



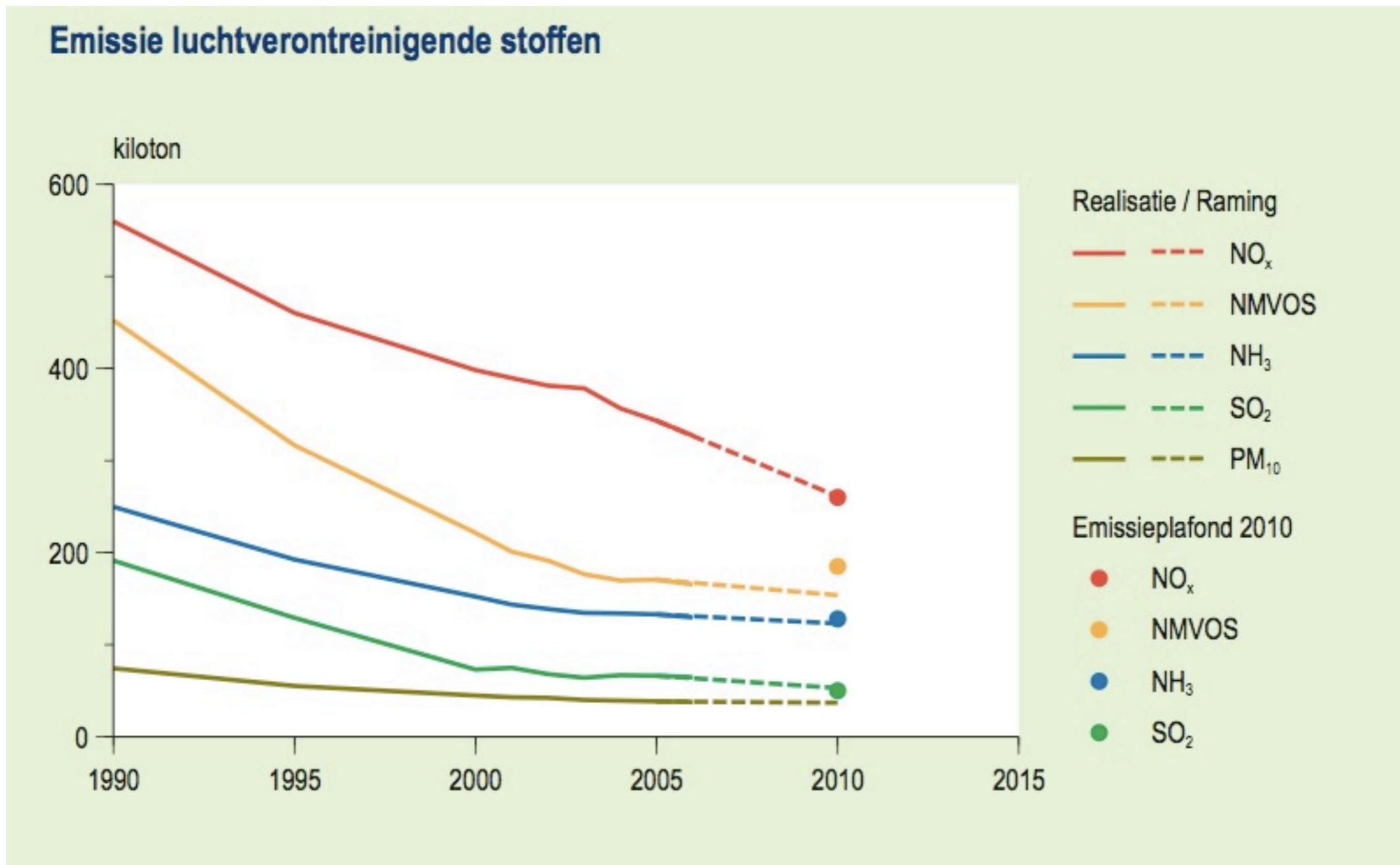


Normen luchtkwaliteit

EU richtlijnen

PM10	40 µg/m ³ 50 µg/m ³	jaargemiddelde daggemiddelde, <35 keer
Ozon	180/240 µg/m ³ 120 µg/m ³	hoogste uurwaarde hoogste 8-uur gemiddelde
NO2	40 µg/m ³	jaargemiddelde

Verbetering luchtkwaliteit in Nederland

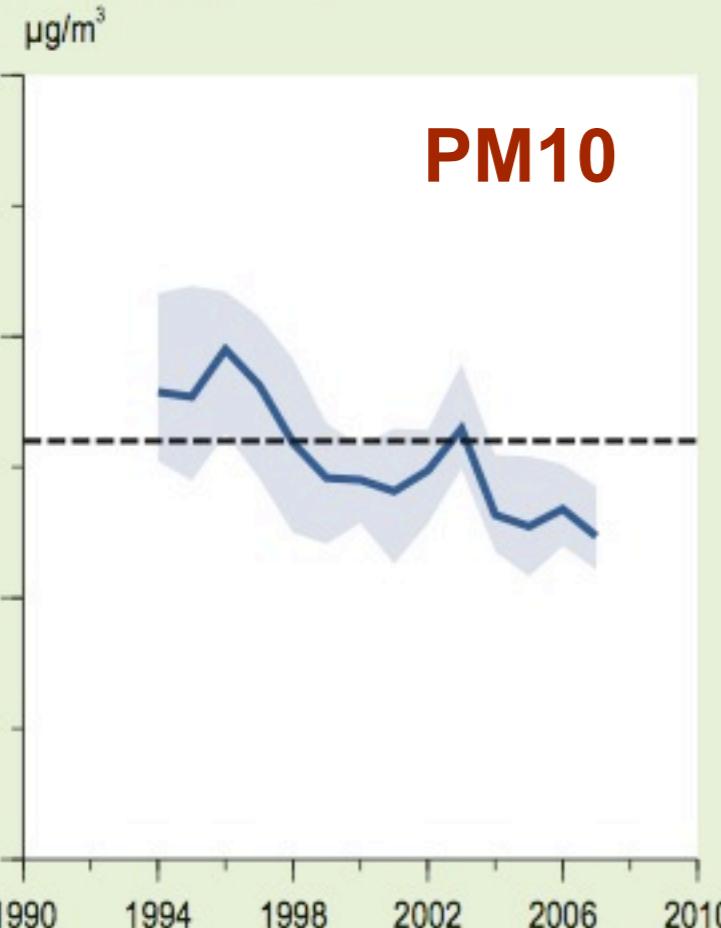


Milieubalans 2008, PBL

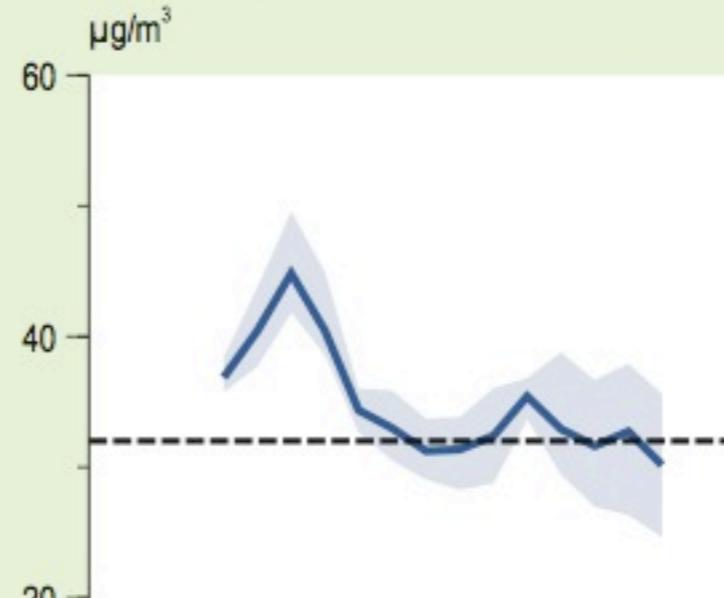


Verbetering luchtkwaliteit in Nederland

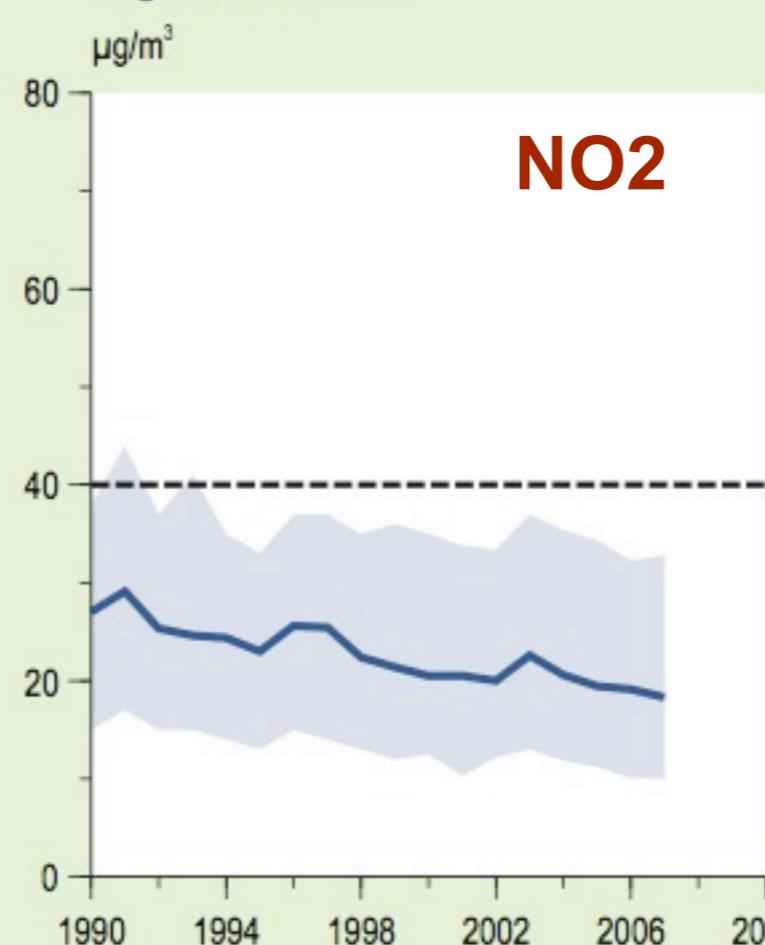
Regionale stations



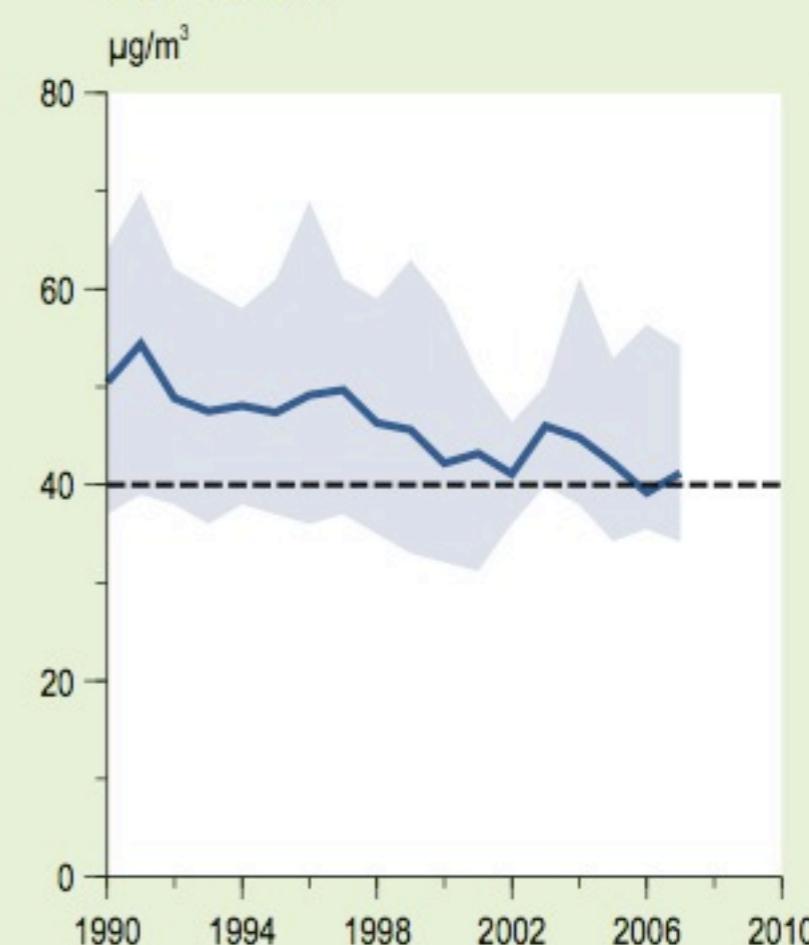
Straatstations



Regionale stations



Straatstations



Milieubalans 2008,
PBL

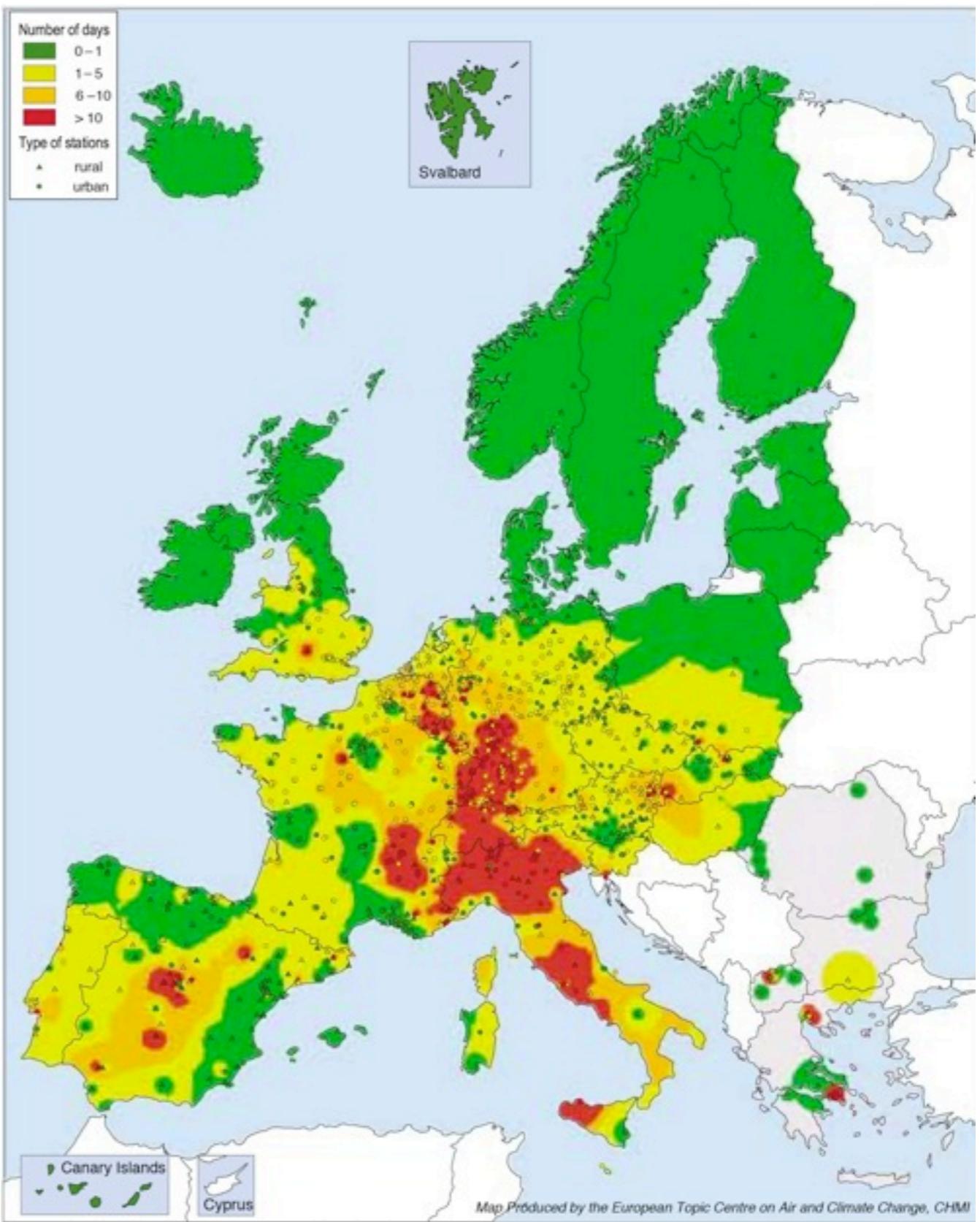
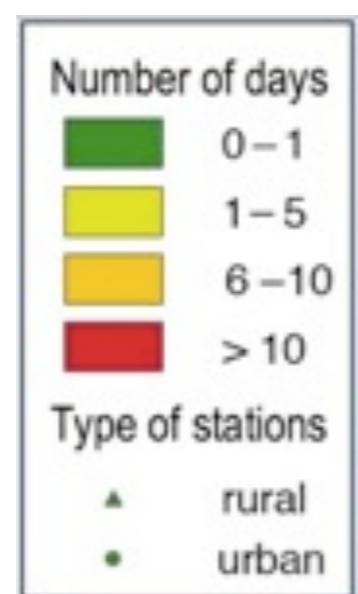


Luchtvervuiling - ozon

Hete zomer 2003

Aantal overschrijdingen van
180 µg/m³ grenswaarde
(informatiedrempel)
april-augustus

Bron: EEA

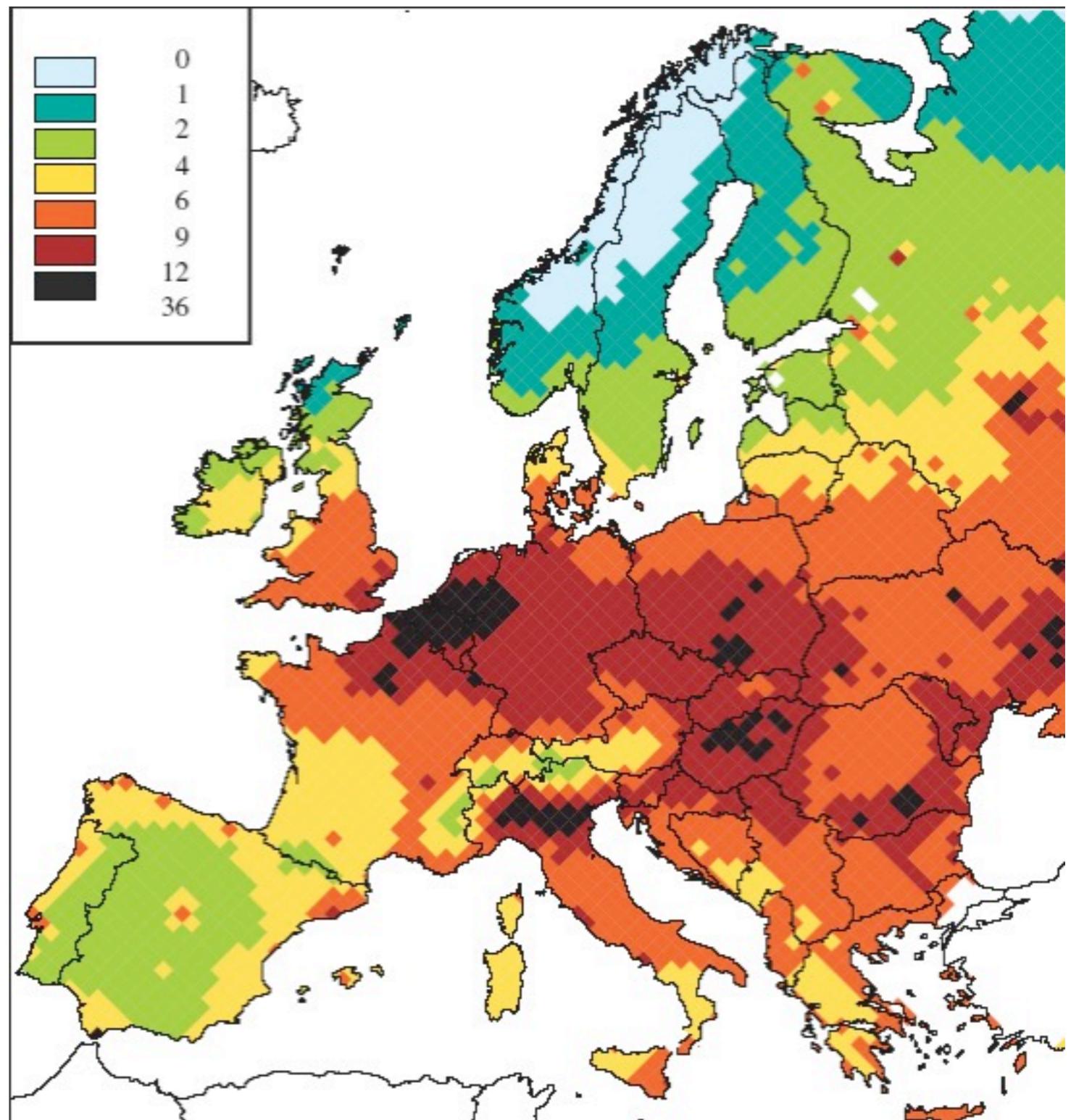


Luchtvervuiling en gezondheid

“Fijn stof”

Verkorting statistische
levensverwachting,
gerelateerd aan antropogene
bijdrages aan PM_{2.5} (in
maanden)

Bron:
CAFE rapport, EU





Satellietmetingen

